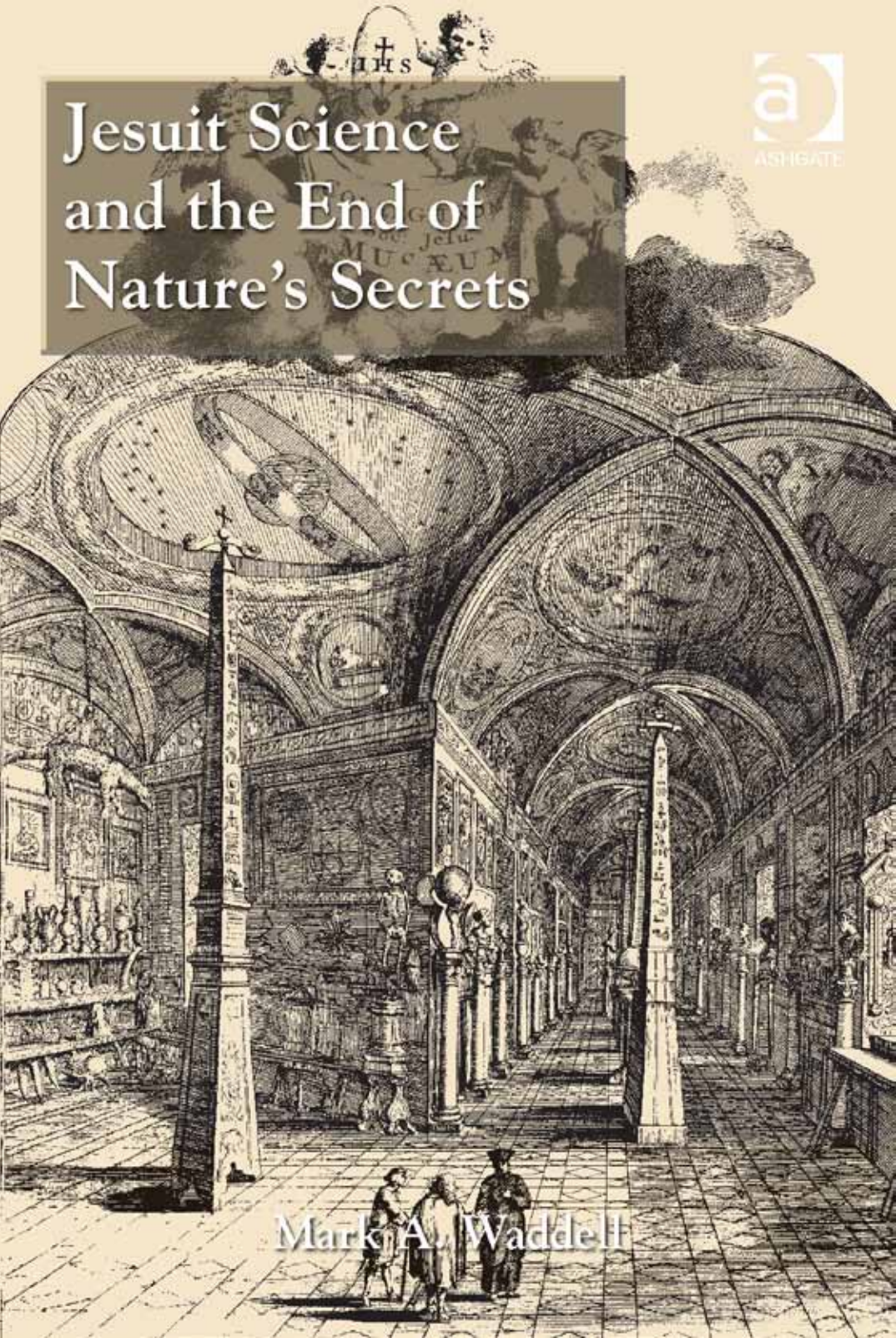
Jesuit Science and the End of Nature's Secrets



Mark A. Waddell

JESUIT SCIENCE AND THE END OF NATURE'S SECRETS

For Maggie

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Introduction

This book is about a quest for clarity, one that took place at a moment of perilous uncertainty for European intellectuals. Beginning in the early sixteenth century, thinkers in Europe began to question the entire endeavor of natural philosophy, thanks in part to the recovery and translation of several ancient works on skepticism. Until this point, Western philosophy had descended almost entirely from Aristotle, who had taught that the only real knowledge was certain knowledge of the causes of things, acquired through both observation and the logical syllogism. The ancient skeptics, however, had taught that certain knowledge was impossible; the most extreme had believed that we can never know anything at all. Sextus Empiricus (ca. 200 CE), who was cited frequently by early modern thinkers, had expanded upon the ideas of Pyrrho of Elis (ca. 360 BCE) by arguing that the appearances of things might offer a way of knowing something about the world, but like Pyrrho and other skeptics, he questioned whether attaining knowledge was possible. Already struggling to assimilate the massive amounts of information flooding into Europe from the New World and Asia, a wide range of thinkers began to question not only the pursuit of knowledge but also the intellectual foundations of Western thought.[1]

Changes in how philosophers conceived of the study of nature affected early modern thought in profound ways. The utility of the senses, especially vision, was called into question to such a degree that some, like René Descartes (1596–1650), devised entire philosophical systems founded on rational thought instead of the senses. Others, like Robert Hooke (1635–1703), embraced technological "crutches" such as the telescope and microscope in an effort to make the eyes

[1] Richard H. Popkin, *The History of Scepticism from Erasmus to Descartes* (Assen: Van Gorcum, 1964); Brendan Dooley, *The Social History of Skepticism: Experience and Doubt in Early Modern Culture* (Baltimore: Johns Hopkins University Press, 1999); Henrik Lagerlund, ed., *Rethinking the History of Skepticism: The Missing Medieval Background* (Leiden: Brill, 2010). On European struggles to assimilate discoveries from the New World, see as examples Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994) and Maria Portuondo, *Secret Science: Spanish Cosmography and the New World* (Chicago: University of Chicago Press, 2009).

more powerful; in his *Micrographia*, Hooke advised "supplying [the] infirmities [of the senses] with *Instruments*, and, as it were, the adding of *artificial Organs* to the *natural*," noting that such an endeavor "has been of late years accomplisht with prodigious benefit to all sorts of useful knowledge, by the invention of Optical Glasses."[2] At the same time, rather than seeking certain knowledge more and more naturalists began to seek only knowledge that was probable or likely. At the Royal Society of London, for example, the self-confessed followers of Francis Bacon (1561–1626) adopted experimental trials and the testimony of reliable witnesses to support their probable claims. The enterprise of natural philosophy changed profoundly, and by the end of the seventeenth century the foundations of modern science had started to take shape.[3]

Shifting conceptions of knowledge were a key part of the changing currents in early modern natural philosophy. Even so, historians of science first linked these developments almost exclusively with the "innovative" reformers of the seventeenth century, men that included Bacon, Descartes, Isaac Newton (1642–1727), and the others that still populate the hagiography of the so-called Scientific Revolution.[4] More recently, scholars of alchemy, natural history, and technology have attempted to expand our understanding of past ideas by focusing not on the familiar traces of modernity glimpsed in the philosophy of the past but, instead, on the complex and varied ways in which early modern people tried to reconcile traditional modes of knowing with a world that seemed to grow larger and more unfamiliar all the time.[5]

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[2] Robert Hooke, *Micrographia* (London, 1665), Preface, pp. 3–4.

[3] Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007); on Descartes, see Raffaella De Rosa, *Descartes and the Puzzle of Sensory Representation* (Oxford: Oxford University Press, 2010) and Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca, NY: Cornell University Press, 2000); on the experimental culture in the Royal Society see Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985).

[4] Classic examples of this kind of scholarship include Richard S. Westfall, *The Construction of Modern Science: Mechanisms and Mechanics* (New York: John Wiley, 1971) and A. Rupert Hall, *The Revolution in Science, 1500–1750* (New York: Longman, 1983; first pub. 1954).

[5] Examples include Lawrence M. Principe, *The Aspiring Adept: Robert Boyle and his Alchemical Quest* (Princeton, NJ: Princeton University Press, 2000); William R. Newman and Lawrence M. Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002); Allison B. Kavey, *Books of Secrets: Natural Philosophy in England, 1550–1600* (Champaign: University of Illinois Press, 2007); Deborah E. Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven: Yale University Press, 2007); Brian W. Ogilvie, *The Science of Describing:*

Modern scholarship, however, has struggled to accommodate the role played by religion in the formation of scientific ideas. Our understanding of the past has come a long way since Robert Merton first articulated his famous thesis in which he linked Puritanism with the rise of modern science; we now have a clearer sense of how early modern thinkers of all confessions sought to reconcile their religious convictions with the changing scientific culture of the time.[6] Because many of those in Catholic orders were constrained by Church doctrine and politics, however, they often found it difficult to endorse publicly some of the novel theories that emerged in the sixteenth and seventeenth centuries, and this seeming reticence on the part of many Catholic intellectuals has made it easier for contemporaries and historians alike to overlook these contributions to the history of science.

Foremost in such contributions were the Jesuits, the colloquialism applied to members of the Society of Jesus, which was founded in 1540 with the approval of Pope Paul III and led for almost two decades by Ignatius Loyola (1491–1556). Ignatius conceived of the Society originally as an order of itinerant missionaries, and within a decade of its founding its members began to spread throughout the known world. Even before Loyola's death in 1556, however, the direction of the Society started to change. Though Jesuit missionaries continued to travel to far-flung corners of the world, education became increasingly central to the Society's larger mission. Their colleges multiplied across Europe and beyond, founded wherever Jesuit missionaries and educators could establish a lasting presence, and it was in and around these colleges that the Jesuit study of the sciences took root.[7]

The precepts that governed Jesuit life and thought demanded public adherence to the philosophical doctrines of Aristotle. Throughout the seventeenth century, however, Aristotelianism was under attack in the universities, coffeehouses, and salons of an increasingly skeptical Europe, and

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Natural History in Renaissance Europe (Chicago: University of Chicago Press, 2006); Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004).

[6] R.K. Merton, "Puritanism, Pietism, and Science," *The Sociological Review*, vol. 28 (1936), pp. 1–30. For examples of more recent and nuanced scholarship, see John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991); Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge: Cambridge University Press, 2001); Thomas Dixon, Geoffrey Cantor, and Stephen Pumfrey, eds., *Science and Religion: New Historical Perspectives* (Cambridge: Cambridge University Press, 2010).

[7] John W. O'Malley, S.J., *The First Jesuits* (Cambridge, MA.: Harvard University Press, 1995).

this explains in part why Jesuit philosophers and mathematicians tend to occupy an ambiguous place in histories of intellectual change. Some modern historians have claimed that the Jesuits, as a whole, contributed relatively little to the advancement of science.[8] Others have argued that Jesuit scientific activity was routinely subordinated to religious goals and that scientific work as such was seen as valuable only insofar as it contributed to the spiritual mission of the Society.[9] Such an interpretation would seem to be reinforced by statements like those made by a close confidant to Ignatius, Jéronimo Nadal (1507–1580), who once wrote that "for us lessons and scholarly exercises are a sort of hook with which we fish for souls."[10] Nonetheless, some historians have argued that the apostolic and spiritual goals of the Society and its repeated insistence on seeing all works as *ad majorem gloriam Dei*, "to the greater glory of God," actually left a wide latitude for philosophical and scientific pursuits that did not directly contradict religious orthodoxy. Others, however, see the affirmations of piety that appear often in Jesuit works as a means of satisfying the Society's censors but not necessarily indicating a genuinely spiritual or pious dimension to the endeavors of all Jesuit philosophers and naturalists.[11]

Thus, what exactly constitutes "Jesuit science" remains a thorny question for modern scholars, much as it did for early modern Jesuits themselves. Philosophers within the Society of Jesus were constrained by the rules that defined their intellectual lives, and their works subject to censorial oversight. In spite of these restrictions, however, the Jesuits of the seventeenth century were not marginal or ambivalent participants in the intellectual culture of their day. As this study will demonstrate, some highly visible members of the Society

[8] Examples of such scholarship include Paolo Rossi, "The Scientist," in *Baroque Personae*, ed. R. Villari (Chicago: University of Chicago Press, 1995), pp. 285–6; Isabelle Pantin, "Is Clavius Worth Reappraising? The Impact of a Jesuit Mathematical Teacher on the Eve of the Astronomical Revolution," *Studies in the History and Philosophy of Science*, vol. 27 (1996), pp. 593–8.

[9] For example, Steven J. Harris, "Transposing the Merton Thesis: Apostolic Spirituality and the Establishment of the Jesuit Scientific Tradition," *Science in Context*, vol. 3 (1989), pp. 29–65.

[10] Jéronimo Nadal, *Exhortatio Coloniensis 6a* (1567), in *P. Hieronymi Nadal Commentarii de Instituto Societatis Iesu*, ed. Michael Nicolau, S.J., vol. 5 (Rome: Monumenta Historica Societatis Iesu, 1962), p. 832, n. 21.

[11] On the latitude sometimes afforded to Jesuit science, see Paul Richard Blum, "Apostolato dei Collegi: On the Integration of Humanism in the Educational Programme of the Jesuits," *History of Universities*, vol. 5 (1985), pp. 101–15; on the secular rather than pious motivations of some Jesuits, see Mordechai Feingold, "Jesuits: Savants," in Feingold, ed., *Jesuit Science and the Republic of Letters* (Cambridge, MA.: MIT Press, 2003), esp. p. 7 and passim.

dared to question the fundamental tenets of their shared philosophy, grappling with questions about certainty, the utility of the senses, and their implications for the study of nature.

This book examines the ideas of several prominent Jesuit authors whose published works focused on the secrets of nature, and follows their efforts in the seventeenth century to expose and, ultimately, to banish these secrets from the realm of natural philosophy. Collectively, these men shaped an innovative methodology in which natural philosophy, imaginative visualization, and the ingenuity of artifice worked in concert to present a vision of the world free of obfuscation and uncertainty.

Seeing and Knowing in Jesuit Culture

My interest in the Jesuit study of the insensible was sparked originally by a consideration of the meditative art produced within the Society in the sixteenth and seventeenth centuries. The complex ways in which Jesuit novices learned to negotiate the path to spiritual illumination depended upon the integrated exercise of the senses, particularly vision, and the imagination. By using imagery to stimulate both the eyes and the mind, certain meditative texts inculcated a rigorous methodology that encouraged the imaginative visualization of places, individuals, and abstract ideals that were otherwise unavailable to the direct experience of the senses. Given that such methodologies were well established within the novitiate curriculum of the Society by the early years of the seventeenth century, I found myself wondering if, and how, these methodologies might have influenced the study of nature, and particularly the study of its secrets. This book is the fruit of those early speculations.

At first glance, the idea that Jesuit naturalists could dedicate themselves to the study of such phenomena is problematic. They were obliged by the rules of the Society to teach and defend the ideas of Aristotle (at least while those ideas did not contradict their faith), and because Aristotelian philosophy concerned itself only with causes that fell within the regular course of nature, the hidden causes of extraordinary phenomena were necessarily deemed indemonstrable. A major component of my argument here, however, is that certain Jesuits consciously and deliberately laid the groundwork for an intellectual shift *away* from the tenets of Aristotelianism; thus, it should come as little surprise that they might do so by studying nature's secrets and their ontological home, the preternatural.

I will describe in this study two main motivations that drove some Jesuits to expose the secrets of nature: on the one hand, a desire to impose greater

clarity on an increasingly fractured and uncertain ontology, and on the other, a perceived need to respond to the sharp and frequent challenges leveled at the Society's Aristotelian philosophy in this period. Thus, the Jesuit study of natural secrets was tied intimately to larger concerns that preoccupied the vast majority of early modern thinkers: who possessed the right to order and define the world, and how they should do so.

In examining both the spirituality and training of early modern Jesuits, I have come to see elements of thought and practice that lend themselves to both the study and revelation of the unseen. Jesuit novices were trained in techniques of imaginative visualization designed to render visible a range of insensible subjects—by no means unheard of in Christian meditation, but expressed and elaborated upon with careful precision by Jesuits in this period. Pioneered by the Society's founder, Ignatius Loyola, and developed further by his successors, Jesuit spirituality focused primarily on the figure of Christ and encouraged the active participation of both the senses and the imagination in the act of spiritual communion with God. Its roots lay in varied traditions of medieval piety, but it received its most comprehensive articulation in the *Spiritual Exercises*, the rigorous program of self-reflection and meditation drawn up by Ignatius and revisited annually by every member of the Society. Ignatius designed the *Exercises* so that an individual could complete them in about a month, dividing the content into a series of four "weeks" during which the exercitant converted himself from a common sinner to a penitent servant of God and the Church.

The conversion envisioned by Ignatius involved the exercitant's rigorous self-identification with the suffering Christ and subsequent joy at Christ's resurrection and ascension, endeavors that he framed almost entirely in sensual and imaginative terms. Ignatius borrowed this emphasis on the sensual from earlier articulations of Christian piety, most particularly those which precipitated his own spiritual awakening as a young man. One of those sources was the *Vita Jesu Christi*, or *The Life of Christ* by the Carthusian Ludolph of Saxony, a popular fourteenth-century work that repeatedly exhorted the reader to imagine himself as part of the described scenes taken from events in the life of Christ. Ludolph's *Vita* descended from a meditative tradition that stretched back to Bonaventure's *The Mind's Journey to God*, where he argued that "[all created things] are examples, or rather exemplifications set before our still unrefined and sense-oriented minds, so that by the sensible things which they see they might be transferred to the intelligible which they cannot see."[12]

[12] George E. Ganss, S.J., ed., *Ignatius of Loyola: The* Spiritual Exercises *and Selected Works* (New York: Paulist Press, 1991), p. 19.

The method embodied in the *Exercises* involved the visual and imaginative representation of those things singled out as foci of the meditative act, even those that were hidden or impossible to see directly. These could be abstract ideas like the quality of divine mercy or a historical scene from the life of Christ, but no matter how difficult it might be to "see" such things, they become real and tangible for the individual following the *Spiritual Exercises* through imagined scenes and sensual descriptions.[13] The *Exercises* urged the exercitant to place himself fully within the description provided, drawing on his imagination to create an intense visualization of the scene and those inhabiting it. One finds an important example of imaginative visualization in repeated instances of the "composition of the place," a kind of visualization that depended almost entirely on sensual impressions; these might include a room where Christ had stood, or a hillside where Mary had rested. A particularly effective example in the *Exercises* is the description of Hell, with detail provided for each of the five senses: "See in imagination the vast fires, and the souls enclosed, as it were, in bodies of fire ... hear the wailing, the howling, cries, and blasphemies against Christ our Lord and against His saints ... smell the smoke, the sulphur, the filth and corruption ... [*etc.*]."[14]

The mingled use of the senses and the imagination that pervades the *Exercises* came to characterize Jesuit spirituality in this period, but also gives us a way of understanding how and why particular Jesuits approached the problem of insensible causation in nature. It is critical to understand that this manner of contemplation—this steady movement between seen and unseen—was not an occasional preoccupation for Jesuits living in the seventeenth century. As members of communities whose daily rhythms were dictated by religious observance, prayer, and the sensual, imaginative contemplation designed by Ignatius and his successors, it would have become a habit of mind, an oft-repeated way of thinking about God and His creation. We do not need those Jesuits at the heart of this book, individuals like Athanasius Kircher (1602–1680) or Niccolò Cabeo (1586–1650), to tell us that this intense contemplation of the unseen lay at the very center of their lives as Jesuits. We know that it did, just as we know that these men, and other naturalists and philosophers within the Society of Jesus, would have engaged in forms of spiritual activity such as that laid out in the Ignatian *Exercises* at the same time that they were writing works on the natural world. There can be no doubt that the uniquely Jesuit methodology of

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[13] David Freedberg, *The Power of Images: Studies in the History and Theory of Response* (Chicago: University of Chicago Press, 1989), p. 180.

[14] Ignatius Loyola, *The Spiritual Exercises*, points 65–70.

contemplating the unseen would have played a central role in the lives of highly placed philosophers within the Society, and thus it is eminently sensible that these thinkers should have turned those strategies of imaginative visualization, image-making, and meditative contemplation to the philosophical study of nature's secrets.

Mathematics Within the Society

The kind of contemplation inculcated within the early modern Society of Jesus demanded that one move between the concrete and the abstract, and from the visible to the unseen. Importantly, this kind of intellectual movement is also central to mathematics, which deals in both the idealized and the mundane. This similarity provides a useful link between the spiritual practices of the Society of Jesus and the way in which those practices were applied to the study of nature, particularly in the realm of mathematics. As many early thinkers understood it, mathematics was inherently abstract, describing not the actual world but an idealized version of it. Ancient followers of Pythagoras had taught that mathematical correspondences dictated the nature of the cosmos, an unseen framework on which physical reality rested, while Aristotle had struggled to reconcile his physics with a mathematics that seemed divorced from the qualitative motion and change that, for him, defined nature.[15] In the sixteenth and seventeenth centuries, however, mathematics assumed an increasingly prominent role in the study of nature, becoming intertwined as it did so with wider philosophical questions; no longer seen as merely one way of describing particular phenomena, it became, for some, the best way to do so.

The epistemic questions raised by the mathematization of nature were grounded, first and foremost, in notions of certainty: proponents of mathematics in the sixteenth century frequently emphasized the certainty of mathematical axioms and demonstrations. The seventeenth century, however, saw these assumptions complicated in numerous ways, not least among them an increasing desire to connect mathematical reasoning with the increasingly practical and experiential character of natural philosophy. At the same time, attempts to conceptualize the universe as a vast machine encouraged early modern philosophers to analyze the

[15] R. Netz, "The Pythagoreans," in Teun Koetsier and Luc Bergmans, eds., *Mathematics and the Divine: A Historical Study* (Amsterdam: Elsevier, 2004); Edward Hussey, "Aristotle and Mathematics," in Christopher Tuplin and Tracey Elizabeth Rihll, eds., *Science and Mathematics in Ancient Greek Culture* (Oxford: Oxford University Press, 2002), pp. 217–29.

varied parts of nature with respect to the laws of mathematics and, more specifically, the (mathematically derived) laws of motion.[16]

By the time Niccolò Cabeo, Athanasius Kircher, and Gaspar Schott (1608–1666) set about redefining the study of insensible phenomena within the Society of Jesus, they did so as part of an intellectual culture that had already grappled with fundamental questions of seeing and knowing, not only within Jesuit meditative traditions but also within the context of applied mathematics. These authors all came to depend upon the singular experience in their efforts to study the insensible parts of nature, shifting their focus away from the evident demonstration of causes derived from collective or universal assent that traditionally had characterized Aristotelian epistemology. Likewise, they each embraced the intervention of artifice, seeing a powerful tool for revelation in its capacity to imitate nature. Both of these practices—the dependence upon singular experiences and the use of artifice—had, by the early decades of the seventeenth century, become enshrined in the myriad disciplines that constituted what early modern people called "mixed mathematics," which applied mathematical methods to a wide range of endeavors and which rose to intellectual prominence in this period.

Before individual Jesuits could benefit from these new ways of studying and manipulating nature, however, mathematicians within the Society first had to convince their peers that the study of mathematics was both valid and philosophically profitable. Though mathematics appeared in the *Ratio studiorum* of 1599, which codified the general curriculum that was to be taught in the Society's schools, before this there existed relatively little institutional support for the study of mathematics within the Society. This fact was rooted in a widespread reluctance on the part of philosophical instructors in the Society's colleges to affirm mathematics as a discipline on equal footing with physics. Mathematics, many claimed, could not provide the kind of information that had long been considered essential to the study of nature: certain demonstrations of causes.

Christoph Clavius (1538–1612), one of the Society's greatest mathematicians, set out to demonstrate that mathematics should be taught as a properly philosophical enterprise, capable of attaining real knowledge about the world. Writing in the 1580s, he placed mathematics on a hierarchical scale between physics, which studied material phenomena, and metaphysics, which concerned itself with subjects divorced from matter. Mathematics, according to Clavius,

[16] Michael Mahoney, "The Mathematical Realm of Nature," in Daniel Garber and Michael Ayers, eds., *The Cambridge History of Seventeenth-Century Philosophy*, vol. 1 (Cambridge: Cambridge University Press, 2003), p. 704.

used hypothetical entities abstracted from matter to describe material objects, lending it a potentially unique position in Aristotelian philosophy.[17] Therein, however, lay the difficulty: one of the most serious objections to mathematics concerned the ontological status of its subjects, which were abstracted from the physical world and were not considered "real" in the same way as the subjects of Aristotelian physics. The task faced by Clavius, and by disciples such as Christoph Grienberger (1561–1636), involved a wholescale redefinition of the pursuit of knowledge, as well as a movement away from the syllogistic and sense-based aspects of late-sixteenth century Aristotelianism.[18]

The legitimacy of mathematics received considerable support from a theological debate concerning divine grace between the Jesuits and the Dominicans around the turn of the seventeenth century, another example of the mutual interaction of philosophy and theology within the Society. In that debate the Jesuits posited the concept of a *scientia media*, a "middle way" of knowing, and used this to justify their claim that God could have a certain knowledge of hypothetical objects (considered, in the "pure" Thomism espoused by the Dominicans, to be an impossibility). The advent of this *scientia media* meant that "the dichotomy between the hypothetical and the real, the practical and the speculative, the necessary and the probable, was ignored."[19] This blurring of lines permitted the followers of Clavius to argue that one could still arrive at a knowledge of (hypothetical) mathematical entities that was no less certain than that of physical causes.

In the wake of Clavius's efforts, both mathematicians and astronomers within the Society were instrumental in altering the resolutely Aristotelian orientation of Jesuit philosophy by embracing new ideas about experience.[20] In particular, Jesuit mathematicians focused on the utility of the singular experience fashioned by the use of apparatus or artifice, a theme that would be deployed most effectively in the spectacular museum of Athanasius Kircher and its links with

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[17] Peter Dear, "Jesuit Mathematical Science and the Reconstitution of Experience in the Early Seventeenth Century," *Studies in History and Philosophy of Science*, vol. 18, no. 2 (1987), p. 139. See also Romano Gatto, "Christoph Clavius' 'Ordo Servandus in Addiscendis Disciplinis Mathematicis' and the Teaching of Mathematics in Jesuit Colleges at the Beginning of the Modern Era," *Science and Education*, vol. 15 (2006), pp. 235–58.

[18] For more on Clavius and Grienberger, see Ugo Baldini, "The Academy of Mathematics of the Collegio Romano from 1553 to 1612," in Feingold, ed., *Jesuit Science and the Republic of Letters*, pp. 47–98.

[19] Rivka Feldhay, "Knowledge and Salvation in Jesuit Culture," *Science in Context*, vol. 1, no. 2 (1987), p. 207.

[20] Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), p. 32.

the growing culture within the Society of public mathematical demonstration.[21] Traditionally, Aristotelian knowledge had depended to a significant degree on universal experience: that which was experienced by everyone was deemed demonstrably certain in a way that a singular experience could not be. A contrived event, whether a discrete observation made using a telescope or a single experiment of the kind reported by virtuosi like Robert Boyle, was sharply and inevitably circumscribed by circumstance, and its utility to natural philosophy was similarly limited.[22] Consider, for example, the misgivings of Christoph Scheiner (1573–1650), one of the most prominent Jesuit astronomers of the period. In his *Oculus* of 1619 he expressed reservations about the deliberate manipulation of contrived experiences, and articulated a profound concern about the artificial interference of instruments such as the telescope, which restricted sharply the numbers of people to whom phenomena were available for observation. Only by creating a means of observing celestial phenomena like sunspots without the aid of a telescope could a properly Peripatetic science become possible; divorcing astronomy from such artificial assistance meant that such phenomena were now accessible "to the eye of anyone."[23]

What preoccupied many of these debates within the Society of Jesus was a growing desire to reconcile singular and contrived experiences with the Aristotelian necessity for the collective or universal experience. In seeking to legitimize such a methodology, of course, proponents of mathematics were far from alone. Historians have demonstrated that early modern thinkers employed a range of strategies to legitimize the use of contrived experiences; the oft-cited example is that of Robert Boyle and his contemporaries in the Royal Society of London, who took great pains to present such contrived events as valid knowledge-claims that could support legitimate philosophical conclusions. Herein lay another, related challenge: namely, how to represent a series of singular, contrived experiences in a fashion that would win general assent from one's audience. Boyle chose to provide his audiences with such circumstantial detail that they became "virtual witnesses," localizing and describing his experiments so precisely that his readers could almost believe they were there themselves.[24] Interestingly, his strategy was not really all that different from the

[21] On this culture of public demonstration, see Rivka Feldhay, "On Wonderful Machines: The Transmission of Mechanical Knowledge by Jesuits," *Science and Education*, vol. 15 (2006), pp. 151–72.

[22] Dear, *Discipline and Experience*, pp. 51–3.

[23] Dear, *Discipline and Experience*, p. 104.

[24] Steven Shapin, "Pump and Circumstance: Robert Boyle's Literary Technology," *Social Studies of Science*, vol. 14 (1984), pp. 481–520.

"composition of place" created by Ignatius as part of the *Spiritual Exercises*—in both cases, they encouraged the reader to imagine himself actually to have been present, and thereby to have "seen" the event in question.

From the efforts of Clavius to find a place for mathematics in Peripatetic epistemology to Scheiner's struggles with the legitimacy of the singular, contrived experience, prominent members of the Society of Jesus wrestled for decades with basic questions concerning knowledge, observation, and experience. Importantly, they did so when confronted by circumstances and practices that frustrated the act of seeing: a geometrical abstraction; sunspots that could be observed only with the aid of a telescope; a singular experiment witnessed by a select few. In every case, the challenge was to communicate the particulars of this unseen thing to an audience who could not see it for themselves. The Jesuits were far from alone in facing this challenge; it also preoccupied naturalists in the New World and beyond, who struggled to codify a means of conveying information about exotic flora and fauna to contemporaries back in Europe.[25] Nonetheless, the Jesuits had to confront this problem within the confines of an Aristotelian epistemology that prized the certain demonstration of causes and the evident empiricism of the senses. There is, consequently, no small irony in the fact that the Society's identity simultaneously constrained its members within this epistemological framework while, at the same time, offering them a range of strategies and tools with which they might work around these institutional limitations.

Into the Unseen

In the following chapters, I will show how particular Jesuits responded to a series of contemporary crises in early modern natural philosophy. These individuals argued for substantial changes to Aristotelian philosophy, particularly the rejection of occult qualities and their substitution by other, more meaningful ways of categorizing and explaining insensible phenomena. In some cases, too, we find explicit rejections of certainty as the gold standard for philosophical explanations, another important epistemic shift in early modern Aristotelianism. Like their contemporaries, these Jesuits struggled to reconcile seeing and

[25] Although focused on the eighteenth century, the work of Daniela Bleichmar explores in excellent detail the problems faced by these naturalists; see her *Visible Empire: Botanical Expeditions and Visual Culture in the Hispanic Enlightenment* (Chicago: University of Chicago Press, 2012), as well as "Learning to Look: Visual Expertise Across Art and Science in Eighteenth-Century France," *Eighteenth-Century Studies*, vol. 46, no. 1 (2012), pp. 85–111.

knowing, dwelling on the problems inherent in the act of seeing before offering solutions to these problems, solutions sometimes rooted in the use of artifice and technology. Yet they also embraced the utility of vision, using images and spectacles to make manifest a range of insensible forces and phenomena. This bewildering, almost paradoxical struggle was shared by others in the seventeenth century; indeed, in some important ways it was emblematic of the wider struggles fought within and around the practice of natural philosophy in this period.

This study centers on Jesuit intellectuals in Europe rather than including the ideas and works of their contemporaries who were active in Asia, the Americas, and elsewhere. Some of the philosophical and methodological challenges faced by these individuals were similar to those encountered by the Jesuits, as I have already suggested. In both cases, the main problem involved making manifest those parts of nature that others could not see or experience directly. While there exists a great deal of excellent scholarship on the science practiced and disseminated by Jesuit missionaries and naturalists overseas, I focus on individuals tied intimately to the Society's colleges in Europe and to the center of Jesuit influence in Rome. Immersed as they were in European scientific culture, they were able to respond more quickly and comprehensively to the intellectual changes that characterized the seventeenth century, and because their works circulated more widely and easily than did those arriving from overseas their ideas were likely to have reverberated more strongly.[26]

Most of this study centers on three figures: Niccolò Cabeo, Athanasius Kircher, and Gaspar Schott. They were not the only Jesuits to focus on the problem of nature's secrets, but they were among the most prominent and widely read of those within the Society of Jesus who dedicated the bulk of their works to the study of insensible phenomena. They were connected in ways that are useful for the historian, by philosophical interests as well as by circumstance. Kircher, for example, followed closely in Cabeo's footsteps in his work on the magnet, and Schott studied with Kircher at various points over many years. They also represent a continuity of ideas across almost forty years, a fact which suggests that their concern with the hidden realms of nature was part of a sustained

[26] On Jesuit science beyond Europe, useful examples include Andrés I. Prieto, *Missionary Scientists: Jesuit Science in Spanish South America, 1570–1810* (Nashville: Vanderbilt University Press, 2011); Florence C. Hsia, *Sojourners in a Strange Land: Jesuits and their Scientific Missions in Late Imperial China* (Chicago: University of Chicago Press, 2009); Steven J. Harris, "Mapping Jesuit Science: The Role of Travel in the Geography of Knowledge," in *The Jesuits: Cultures, Sciences, and the Arts, 1540–1773*, John W. O'Malley, S.J., Gauvin Alexander Bailey, Steven J. Harris, and T. Frank Kennedy, S.J., eds. (Toronto: University of Toronto Press, 1999), pp. 212–40.

endeavor to adapt the common philosophy of the Society to the enormous changes rippling through early modern intellectual life. Moreover, each of these men was connected closely to the culture of education that prevailed in the Society's many colleges: Cabeo's *Philosophia magnetica* was written in the style of the neo-Aristotelian textbook, Schott spent decades teaching students at colleges in Sicily and Germany, and Kircher was appointed as professor of mathematics at the Collegio Romano, the Jesuit college in baroque Rome.

Together, these three Jesuits exemplified a unified but diverse set of approaches to nature's secrets. Like all of their contemporaries within the Society, they were trained as skilled manipulators of the links between what could be sensed and what could not. The *Spiritual Exercises* and other examples of meditative practice, such as Jéronimo Nadal's *Adnotationes et meditationes in Evangelia*, were central to Jesuit identity in this period.[27] They encouraged a tightly focused attention to the movement between the manifest and the insensible, something that persisted throughout the life of each individual member. In other words, the Jesuits were early modern experts in transforming what could not be sensed by the eyes into something that could be seen by the mind, and thereby understood. This shared identity is worth emphasizing, for Kircher, Cabeo, and those like them were not unique within the Society. They were not outliers, nor really all that unusual. Though of course we should hesitate to leap to the conclusion that all Jesuits thought as these individuals did, it is worth remembering that these particular men were active and accepted members of the Society, trusted to teach and to publish. Indeed, this last point is particularly significant, for publishing has always been carefully regulated in the Society of Jesus: that a Jesuit received permission to publish his ideas suggested that those ideas were, at the least, not embarrassing to the Society, and may even have been embraced, openly or not, by others as well.

Kircher, Cabeo, and Schott each benefited from the pioneering efforts of Clavius and his intellectual heirs, and consequently were able to extol the virtues of the singular, contrived experience that offered insights into the invisible force of the magnet or the unseen depths of the earth. They could question the utility of the senses and embrace instead the exercise of the imagination championed first by Ignatius and then elaborated upon by followers such as Jerónimo Nadal, who made the imagination central to the contemplation of the unseen. They could also exploit the possibilities of imagery and artifice in communicating information about the unseen and unwitnessed parts of nature, as did Scheiner

[27] Walter S. Melion, "Memory, Place, and Mission in Hieronymus Natalis' *Evangelicae historiae imagines*," in *Memory and Oblivion: Proceedings of the Congress of the History of Art* (Dordrecht: Kluwer Academic Publishers, 1999), pp. 603–8.

and others. The point here is not merely that the Jesuits were grappling with many of the same epistemological challenges faced by their contemporaries across Europe; it should no longer come as a surprise that prominent thinkers within the Society were active participants in the large-scale changes sweeping through early modern natural philosophy. What is both significant and interesting is how these Jesuits couched their responses to these epistemological problems. Their expected adherence to at least a nominal Aristotelianism required them to be far more ingenious in how they addressed issues of certainty, experience, and sensualism than those contemporaries who could bluntly dismiss the Peripatetic philosophy, or who could at least pretend to do so.

Some, like Scheiner and his fellow astronomers within the Society, proceeded cautiously, one foot resting squarely in the Aristotelian camp even as they struggled to change attitudes towards the singular experience and the intervention of artifice in the pursuit of natural philosophical knowledge. Others, particularly Kircher and his disciple Schott, constructed sprawling baroque edifices overflowing with ornamentations and contradictions that merely flirted with the fundamentals of Peripateticism. But in all of these cases, individual Jesuits constructed complex strategies that allowed them to work within the institutional confines of their Society while simultaneously innovating upon their shared philosophy and taking it into the uncharted realms of the unseen.

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Chapter 1
The Crisis of Certainty

The Jesuits' struggles with uncertainty came at a time when natural philosophers across Europe found themselves wrestling with the stubborn intransigence of Nature, with its refusal to reveal its secrets to their collective gaze. Nowhere was this struggle more obvious, or more freighted with anxiety, than in the study of insensible causes. Almost everyone accepted that the natural world overflowed with unseen phenomena and causes, from the invisible power of the lodestone to the mysterious forces deep within the Earth that produced earthquakes and volcanism. Where and how such phenomena became manifest to the gaze of early modern naturalists—and their implications for theology, philosophy, and early modern culture more broadly—consequently became the central questions of the age.

On its own, the problem of insensibility raised inevitable concerns about the utility and fallibility of the senses. Insensible, but seemingly natural events posed a conflict with the empirical mode of knowing embraced first by Aristotelian philosophy and, later, by proponents of the "new philosophies." These debates about certainty, probabilism, and vision characterized what I call the crisis of certainty. In its broadest terms, this crisis embodied the widespread rise of skeptical inquiry throughout the sixteenth century, which led many thinkers to abandon the quest for certainty and to embrace instead various kinds of probabilism. For the ancients, skepticism had been a response to dogmatism (the claim that one could and did know some truth about how things really are) and generally fell into two main camps: the Academic skepticism that originated in the Platonic Academy held that knowledge was simply unattainable, while the Pyrrhonian skepticism advocated by Sextus Empiricus and others posited that, without sufficient evidence to indicate whether attaining knowledge was possible, one should stop short of the position taken by the Academics and instead merely suspend any and all questions concerning the pursuit of knowledge.[1]

The Academic skeptics in particular went to great lengths to demonstrate why dogmatic statements of truth were inherently flawed: because knowledge

[1] Richard H. Popkin, *The History of Scepticism from Erasmus to Descartes* (Assen: Van Gorcum, 1964), p. ix.

about the world inevitably includes claims that transcend simple empiricism or observation, all knowledge must depend either on sense-impressions or reasoning, and because either or both could be unreliable, we can never have a guarantee of true knowledge.[2] This was a particularly unsettling line of inquiry for many early modern philosophers. Francis Bacon, for example, inveighed against it in his 1609 *Redargutio philosophorum* when he said, "This Academic school, which avowedly held [the doctrine of] Acatalepsy, has damned humankind to perpetual shadows."[3] "Acatalepsy" was a philosophical doctrine held by many ancient skeptics, defined by Ephraim Chambers in his *Cyclopaedia* of 1728 as "the Impossibility of comprehending or conceiving a thing, [or the idea that] all human Science and Knowledge ... went no further than to Appearances or Verisimilitude."[4] For Bacon, as for many of his contemporaries in the seventeenth century, this was a radical position that, if adopted, would only damage the pursuit of natural philosophy: claims that knowledge was simply unattainable seemed guaranteed to put a halt to the investigation of nature.

By contrast, ancient followers of Pyrrhonian skepticism had seen it as the path to quietude, a state of mind in which one suspended judgment on anything and everything beyond the appearances of things.[5] When Renaissance humanists translated the writings of Sextus Empiricus in the sixteenth century, it was Pyrrhonianism that attracted the attention of a range of thinkers, who saw in its judicious refusal to accommodate dogmatism a new way of studying and understanding the natural world. This did not mean that more extreme forms of Pyrrhonianism did not exist as well, and even the more moderate positions of Pyrrho and Empiricus sometimes led to conclusions as destructive to the pursuit of knowledge as anything proposed by the Academics. Thus, as the pendulum swung away from the Peripatetic philosophy still taught in the universities, some thinkers saw the need for a *via media*, a middle way that lay somewhere between the destructive consequences of extreme skepticism on the one hand and the increasingly untenable dogmatism of the schools on the other. Marin Mersenne (1588–1648), the Jesuit-educated mathematician and Minim friar, argued for a mitigated skepticism, a more constructive path that allowed for probable

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2 Popkin, pp. ix–x.

3 Francis Bacon, *The Works of Francis Bacon*, ed. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath (London: Houghton Mifflin, 1857), vol. VII, p. 88: "Hinc schola Academica, quae Acatalepsiara ex professo tenuit, et homines ad sempiternas tenebras damnavit."

4 Ephraim Chambers, *Cyclopædia, or, An universal dictionary of arts and sciences* (London, 1728), p. 14.

5 Popkin, p. xi.

claims based on observation and experience. It was a lesser form of knowledge by Peripatetic standards but one that, for Mersenne, was at least attainable.[6]

The movement towards probabilism led increasing numbers of thinkers to believe that repeated inquiries conducted by connected groups of naturalists could, in time, produce knowledge about the world that remained likely but that was also subject to verification and testing. Though not "certain," these knowledge-claims were nonetheless highly probable, far more so than mere opinion or conjecture. Collaborations between naturalists became institutionalized in bodies like the Royal Society of London, the Accademia del Cimento in Florence, and the Académie Royale des Sciences in Paris, while increasingly complex networks of correspondence allowed individuals to exchange information about experiments and discoveries across national as well as confessional boundaries. Cooperative inquiry into nature became the cornerstone of the "new science" that emerged in the seventeenth century, permitting the accumulation of probable claims that slowly became the standard whereby knowledge was judged.[7]

The development of novel methods for studying nature did not lack for complications. As one example, the founders of the Royal Society in England attempted to walk a fine line between acknowledging the potential deceit and fallibility of the senses on the one hand and, on the other, utilizing sensory experience in the study of nature. They accomplished this in part by conscripting others to act as witnesses to specific demonstrations, echoing the increasingly collaborative nature of early modern natural philosophy. Fallibility became less of a concern as greater numbers of eyes were called upon to observe and interpret experimental results, and the testimony of witnesses was supported by contemporary standards of conduct and honesty as embodied in the figure of the gentleman-virtuoso.[8] For all the ingenuity displayed by those who sought to bring reason to bear on sense-experiences—the "Descent of Reason upon the short Testimony of Sense," as they put it—the English virtuosi nonetheless reconciled themselves to the idea that, while they could describe the appearances of natural phenomena adequately, their causes might remain a mystery. One could hypothesize or speculate as to those causes, but certitude would be impossible, leading Robert Boyle to claim that men might "fancy themselves

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[6] Popkin, p. 132.

[7] Barbara J. Shapiro, *Probability and Certainty in Seventeenth-Century England: A Study of the Relationships Between Natural Science, Religion, History, Law, and Literature* (Princeton, NJ: Princeton University Press, 1983).

[8] Steven Shapin, *A Social History of Truth: Science and Civility in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994).

Eagles," but were really nothing more than "grovelling Moles incessantly labouring for Light."[9]

In formulating their probabilistic natural philosophy, the English virtuosi in particular frequently opposed its central tenets to the Aristotelianism still taught in the universities, using the latter philosophy as a convenient straw man against which to articulate their own arguments.[10] At the same time, however, numerous proponents of Aristotle were keenly aware of the potential problems posed by the more extreme forms of skepticism, which led them in turn to examine and embrace forms of probabilism as well. The Jesuits, for example, adapted the curriculum of their many colleges to accommodate a form of probabilism in the seventeenth century, embracing what might be seen as the lesser of two evils. Committed as they were to at least a nominal Aristotelianism, Jesuit educators perceived a greater threat in the rise of extreme forms of skepticism than in adopting some elements of probabilism. The latter allowed them to eliminate a reliance on the dogmatic statements of certain knowledge that were the primary target of the skeptics (some of whom displayed an ironically dogmatic insistence that we can never know anything) and instead to couch their ideas in a more flexible language of likelihood. An example of this probabilistic approach was Mersenne himself, who encountered this way of thinking as a student of the Jesuits and whose philosophical orientation remained, in many respects, indelibly marked by his education. Significantly, this movement towards an intellectual probabilism may have permitted Jesuit thinkers to approach different kinds of knowledge, such as mathematics, in new and useful ways, altering the parameters of their shared philosophy in a fashion that I explore throughout this book.[11]

While adopting probabilism offered one potential solution to the crisis of certainty, the senses, which played a crucial role in probabilistic knowledge-claims, became ever more problematic in this period. For centuries, philosophers adopting the Aristotelian model of vision had assumed that our senses provided us with accurate representations of the world, and while some, like Aquinas, conceded that our senses were limited, they remained confident that our eyes

[9] Shapiro, pp. 62, 22.

[10] For a clear understanding of attitudes towards Aristotle in the Royal Society, see Thomas Sprat's *The history of the Royal-Society of London for the improving of natural knowledge* (London, 1667), particularly his discussion of "the Philosophy of the Schole-men" on pp. 15–22.

[11] Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca, NY: Cornell University Press, 1988); see also his *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995); Robert A. Maryks, *Saint Cicero and the Jesuits: The Influence of the Liberal Arts on the Adoption of Moral Probabilism* (Aldershot: Ashgate, 2008).

revealed things as they truly were. In the early modern period, however, a wide range of thinkers and artists began to understand that the act of seeing was far more complicated and unreliable than had been previously believed. The invention of the telescope and, later, the microscope revealed how little of the universe naturalists actually perceived, while the increasingly skeptical tone of early modern philosophy forced a radical re-evaluation of both the value of empiricism and the senses that supported it.

Thus, in numerous aspects of early modern life ranging from demonology and theatre to painting and philosophy, the pleasures and assumptions that had always accompanied the act of seeing became distinctly more problematic.[12] As confidence in their senses decreased, natural philosophers had little choice but to turn to language and practices that permitted them to make probable statements about natural phenomena based solely on whatever their senses could perceive and whatever they could infer from appearances. Ultimately, when combined with the increasing prominence of skeptical inquiry, early modern philosophers came to agree that the conclusions drawn from visual experience should be presented only as likely or probable, intended to appeal to subjective sensibilities rather than to any objective or dogmatic truth.[13]

At the same time, a slow but significant change took place in contemporary ideas about the imagination. Increasing numbers of early modern thinkers looked to the imagination as a way of maneuvering around the problems associated with sense-perception; its ability to act on the rational mind even in the absence of sense-impressions implied that, as part of the act of cognition, one could divorce the imagination to a degree from the skeptical debates concerning the senses that occupied much of early modern philosophy. Prior to this, the utility of the imagination had been discussed frequently in Aristotelian psychology, where it was understood to mediate between the senses and the rational mind but, also, to function primarily in the absence of sense-impressions. Sometimes this meant that the imagination supplied to the mind impressions of objects that had since been removed—this was the faculty that allowed one to recall, for example, the

[12] For a comprehensive study of these changing attitudes towards vision, see Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007), and also Walter S. Melion and Lee Palmer Wandel, *Early Modern Eyes* (Leiden: Brill, 2010); on the problems raised by the introduction of instruments, see Ofer Gal and Raz Chen-Morris, "Empiricism Without the Senses: How the Instrument Replaced the Eye," in Charles T. Wolfe and Ofer Gal, *The Body as Object and Instrument of Knowledge: Embodied Empiricism in Early Modern Science* (London: Springer, 2010), pp. 121–48; Gyorgy E. Szonyi, "Perception, Vision, Phantasmagoria: Ways of Seeing in the Early Modern Period and Since," *Aries*, vol. 11, no. 1 (2011), pp. 53–75.

[13] Clark, *Vanities of the Eye*, p. 270.

image of a painting that one had seen—but the imagination was also capable of acting in the absence of any object whatsoever, as witnessed in daydreams and fantasies. It was potentially a powerful component of knowing, and while the senses could only relay information about objects, the imagination was free to embellish, manipulate, and construct impressions. This is not to suggest that early modern people saw the imagination as an uncomplicated answer to various epistemological problems. There was in fact a long history of mistrust associated with the imagination, going back to antiquity; Aristotle himself stated at one point that "imaginations are for the most part false."[14]

As the prominence and power of the imagination increased, so too did concerns about its ability to provide the mind with false impressions, to open the intellect to demonically inspired *phantasia*, or even to inflict the individual with melancholia. Nonetheless, the imagination assumed a new and crucial prominence in the sixteenth and seventeenth centuries as thinkers from a range of camps and persuasions struggled to codify a new way of knowing. That the imagination was able to assume this new role had much to do with the changes taking place in early modern theoretical psychology, changes centered around an increasing awareness of the fallibility of both eyes and mind. Thus, the crisis that altered how early modern people understood their own limitations presented opportunities for novel ways of knowing and thinking. Certain elite thinkers among the Jesuits, as we shall see, were well positioned not only to take advantage of these opportunities, but also to display their intellectual versatility by turning their attention to the most difficult of natural philosophical problems: the study of the unseen.

The Problem of the Preternatural

The crisis of certainty acted as a backdrop for a new and, in many cases, critical reassessment of the category of the preternatural, which for centuries had acted as the repository of the secret and unexplained works of nature.[15] Meaning literally

[14] Clark, pp. 44–5. For more on the imagination and its connections with early modern science, see Guy Claessens, "Imagination as Self-Knowledge: Kepler on Proclus' *Commentary on the First Book of Euclid's Elements*," *Early Science and Medicine*, vol. 16, no. 3 (2011), pp. 179–99; Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton, NJ: Princeton University Press, 1995).

[15] Changing understandings of the preternatural lie at the heart of Lorraine Daston and Katharine Park's *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998). Similarly, Stuart Clark discusses the preternatural in the context of early modern

"beyond nature," the preternatural was situated, in the standard ontological hierarchy, between the realms of the natural and the supernatural. The supernatural encompassed God and examples of divine works that transcended natural laws; the realm of the natural, by contrast, was the tangible expression of those laws, containing objects and phenomena that demonstrated how nature normally and consistently worked. While the boundaries that defined these two categories were generally unvarying for most thinkers—at least, there was little disagreement about where those boundaries *should* be—the boundaries of the preternatural were in a constant state of flux, expanding and contracting over the course of centuries. It became a repository for phenomena that did not transgress the basic laws of nature but, rather, that embodied distortions and perturbations of those laws. It was the ontological home of the rare, the hidden, the mysterious, and the monstrous, a catch-all for those things that did not fit easily or comfortably into the placid and well-studied routines of the natural world, and it was its inherent flexibility that made it, for a time, so powerful.

Because the preternatural embodied not the rational and comprehensible laws of nature but, instead, instances when those laws appeared to break down, wrestling with so amorphous and troublesome a category became less and less appealing to early modern intellectuals already grappling with a host of epistemological and philosophical problems. Thus, it is unsurprising that the sixteenth and seventeenth centuries witnessed an increasing desire on the part of naturalists, theologians, and jurists to define more sharply and clearly the ontological borders between things.[16] The flexibility of the preternatural, once seen as an asset, eventually became a problem: it was too likely to obscure the boundaries between the miraculous and the mundane. In the wake of the religious and political turmoil that swept across Europe in the sixteenth and seventeenth centuries, any confusion about what was supernatural and what was not—what was a miracle and what was merely imaginative fancy or demonic imposture—became intolerable. The blurring of lines between categories could and did lead to accusations of heresy, and thence to censure, condemnation, and even death.[17]

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demonology; see his *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Oxford University Press, 1997), in particular the chapters that make up the section on "Science."

[16] Lorraine Daston, "The Nature of Nature in Early Modern Europe," *Configurations*, vol. 6 (1998), pp. 149–72.

[17] While an enormous subject in itself, the history of European heresy is revealing of how this blurring of boundaries was often tied up with accusations of heretical activity; for examples, see Gary K. Waite, *Heresy, Magic, and Witchcraft in Early Modern Europe* (New

The preternatural, then, quickly became problematic for early modern thinkers. It was a negative category, defined not by what it was but by what it was not—that is to say, it embodied neither the regularity of the natural nor the transcendent character of the supernatural. Moreover, as Lorraine Daston and Katharine Park have argued, it was a category "whose limits were defined in practical terms by a pair of unstable criteria both of which depended on the experience and knowledge of the viewer: that which was infrequently experienced or that at which the ignorant wondered."[18] For some early modern philosophers, the preternatural was fundamentally unintelligible; divorced from the usual and intelligible operations of nature, the causes of preternatural phenomena were usually occult or hidden and thus inexplicable.

The inherent subjectivity of personal experience (or ignorance) and the potential for outright unintelligibility, applied over centuries to an ever-changing roster of phenomena, meant that by the seventeenth century the preternatural had become an awkward collection of disparate phenomena, held together by some vague ontological identity but lacking any kind of meaningful coherence as a category.[19] The boundaries that provided some vague form to the preternatural were also inherently unstable: on the one side lay miracles and other instances of divine intervention, which were the subject of intense theological debate in this period; on the other lay the ordinary workings of nature, which were themselves the subject of intense debate among natural philosophers.[20] As these debates continued, they could not help but distort the boundaries that defined the preternatural, and the resulting ontological instability reverberated throughout early modern intellectual culture and beyond, into a widespread and popular preoccupation with prodigies, wonders, marvels, and other examples of nature's seemingly infinite capacity to amaze and astound.

The myriad examples of nature's mysteries defined what we might call the culture of marvels, and its heyday, like that of the preternatural, stretched from the Middle Ages through to the early years of the eighteenth century. Both the preternatural and the culture of marvels were rooted in the understanding

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York: Palgrave Macmillan, 2003); Carlo Ginzburg, *The Cheese and the Worms: The Cosmos of a Sixteenth-Century Miller*, trans. John and Anne Tedeschi (New York: Penguin, 1982); John Tedeschi, *The Prosecution of Heresy: Collected Studies on the Inquisition in Early Modern Italy* (Binghamton, NY: Medieval & Renaissance Texts & Studies, 1991).

[18] Daston and Park, p. 126.

[19] Clark, *Thinking with Demons*, p. 262.

[20] Clark, *Thinking with Demons*, p. 177. On the utility of the preternatural, see also Des Chene's *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca, NY: Cornell University Press, 2000), p. 218.

that, rather than being bound by strict and immutable laws, nature worked in regular but by no means determinate ways. Exceptions to the ordinary course of nature were, if not common, then at least inevitable, and these exceptions were frequently invested with cultural meaning. Inexplicable phenomena such as comets and monstrous births were often interpreted as prodigies, messages or warnings freighted with supernatural meaning, while princes, cardinals, and the upwardly mobile middle classes all constructed variations on the *Kunstkammern*, cabinets of curiosities that became tangible expressions of wealth and erudition as well as of nature's propensity for producing marvels.[21]

Early modern wonders preoccupied a broad swathe of the European population; until roughly the middle of the seventeenth century the preternatural received enormous amounts of attention from philosophers, theologians, physicians, and ordinary people alike.[22] Some thinkers resisted this attention paid to the preternatural; many Aristotelians, for example, deliberately excluded wonders and marvels from natural philosophy in the sixteenth and seventeenth centuries. They found this practice increasingly challenged by a new breed of intellectual, however: the "preternatural philosophers," who not only focused their attention on natural marvels but also sought to rescue these phenomena from the fringes of respectable intellectual discourse and place them instead squarely at the core of the study of nature.[23] Despite the shortcomings of the preternatural, there were important reasons why these philosophers might have found its study useful. By embodying perturbations from the norm, it highlighted what that norm was and how it (usually) operated.

However useful some naturalists found the study of the preternatural, this attention did not last. Its disappearance from most philosophical discourse by the early decades of the eighteenth century might be linked to what historians have called the "disenchantment of nature," whereby Europeans in the late seventeenth century supposedly rejected magical thinking and superstition and turned instead to orthodox religion or rational science.[24] Though it fits

[21] The most comprehensive survey of the culture of marvels remains Daston and Park's *Wonders and the Order of Nature*, but see also Pamela H. Smith and Paula Findlen, *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (New York: Routledge, 2002); on Kunstkammern and the culture of collecting, see Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994); Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004).

[22] Daston, "The Nature of Nature in Early Modern Europe," p. 162.

[23] Daston and Park, p. 160.

[24] On the idea of "disenchantment," see Keith Thomas, *Religion and the Decline of Magic* (New York: Scribner, 1971); Robert W. Scribner, "The Reformation, Popular Magic,

comfortably into progressive narratives of the rise of modernity, however, this notion of "disenchantment" hardly squares with how people lived, wrote, and thought in the seventeenth century. The many marvels of nature continued to fascinate even the supposedly rigorous experimentalists of Europe's scientific societies well into the eighteenth century, and while many rejected claims that such marvels were divine prodigies or diabolical machinations, these exemplars of nature's secrets nonetheless remained subject to intense scrutiny by naturalists throughout this period.[25]

For all of its associated problems, the preternatural was important because any study of nature's secrets, of its hidden properties and forces, inevitably overlapped with the ontological home of such phenomena, and it was precisely these phenomena that became a focus for natural philosophical inquiry in the sixteenth and seventeenth centuries. At the same time, however, early modern philosophers came to see some value in marginalizing and diminishing the preternatural; its inherent and growing instability threatened the entire ontological order of things. They could not afford to embrace a boundary between nature and the divine that was so unstable, and increasingly they sought to establish firm distinctions between these two realms even as they rejected claims and ideas that threatened to blur ontological lines.

Given that the stakes were both theological and philosophical, it is likely that the Jesuits would have been attuned to the problems posed by the preternatural. Indeed, the Catholic Church had long worked to diminish this category as part of its efforts to construct a simplified ontology that reinforced the distance between the miraculous works of God and the mundane workings of nature. Following the Council of Trent around the middle of the sixteenth century, the Church emphasized the importance of miracles, seeing them as a means of legitimizing the Catholic faith. This meant, however, that miracles had to be vetted with extraordinary care, to be certain that each was, in fact, an authentic example of divine activity. This increased vigilance on the part of Church authorities called for firm and irreproachable distinctions between what was properly supernatural and what was not. Thus, when members of the Spanish Inquisition confronted religious enthusiasts and other supposed pretenders to supernatural revelation, they tended both to fortify existing definitions of the supernatural and to naturalize "borderline" phenomena, those that belonged

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and the 'Disenchantment of the World,'" *Journal of Interdisciplinary History*, vol. 23 (1993), pp. 475–94; Charles Webster, "Paracelsus, Paracelsianism, and the Secularization of the Worldview," *Science in Context*, vol. 15 (2002), pp. 9–27.

[25] Daston makes this case eloquently in her "The Nature of Nature in Early Modern Europe."

traditionally to the preternatural but that might blur the ontological boundaries that the Inquisition was so desperate to reinforce. Such phenomena were subjected to the rigors of natural philosophical inquiry and deemed either "properly" natural or fraudulent.[26]

As the supernatural was fortified and the natural expanded, what lay between them—the preternatural—was slowly squeezed towards irrelevance. Well beyond the activities of the Spanish Inquisition, the expansion of "the natural" in European philosophy involved the steady naturalization of the preternatural, in which particular phenomena were singled out and shown to be neither mysterious nor strange. As the rest of this book will demonstrate, an interconnected group of prominent Jesuits engaged enthusiastically in precisely this sort of boundary-work, transforming the wonders of nature into natural and explicable oddities. The result was a diminishment of the preternatural and an end to nature's secrets, in service to greater ontological clarity.

[26] Andrew Keitt, "Religious Enthusiasm, the Spanish Inquisition, and the Disenchantment of the World," *Journal of the History of Ideas*, vol. 65, no. 2 (April 2004), pp. 236–7.

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Chapter 2
Building a Better Ontology

If the preternatural was a problem for early modern thinkers, the obvious solution was to create a new ontology, one in which the all-important lines between nature and God were clear and defensible. Those unusual and exotic phenomena that had cluttered the European imagination for centuries and defined a nebulous, ever-changing category found themselves subjected to intense scrutiny in the sixteenth and seventeenth centuries. For the Jesuits, this scrutiny could and did serve a crucial purpose: the study of phenomena and objects long relegated to the realm of the preternatural became, in Jesuit hands, a means of redefining an ontology that had gone largely unquestioned for centuries.

In this chapter I examine two case studies that demonstrate how different members of the Society of Jesus tackled the problems posed by an outdated and ambiguous ontology. In the first, the Jesuit jurist Martín Antonio del Rio (1551–1608) attempted to define different kinds of magic with reference to the ontology of causes. For Del Rio and most of his contemporaries, "magic" was nothing more than the deliberate manipulation of natural but hidden virtues and forces. The task facing those with an interest in magic was determining whether a particular effect was caused by the ordinary workings of nature, by the preternatural manipulation of natural but inexplicable forces, or by divine intervention. This was not an idle concern; demons, witches, and the Devil himself were thought to manipulate those forces within nature that were most deeply hidden and largely unknown, as part of their efforts to seduce and punish the unwary.

Ontology was thus a central preoccupation of early modern demonology, as were the occult or hidden causes of magical effects. Del Rio was the most prominent member of the Society of Jesus to address the problem of magic in this period, and his *Disquisitionum magicarum libri sex* of 1599 reveals both his struggles with the ontology of occult causes and, ultimately, his failure to establish a reliable means of defining the boundaries between different kinds of magical effects. Because demonology had long been an important arena in which European thinkers considered how and by whom the secret forces of nature were made manifest, Del Rio's failure is illustrative of the challenges facing those who sought to redefine the study of those natural secrets.

In the second case study, we examine how several Jesuits addressed the controversial phenomenon known as the weapon salve or the powder of sympathy, a medical remedy that was thought to heal wounds quickly and painlessly even over distances of many miles when applied only to traces of the patient's blood. Discussed and debated for much of the seventeenth century, the weapon salve posed ontological problems of its own. Its proponents sought to naturalize and legitimize its mysterious power by emphasizing its similarity to the activity of the magnet and to other, natural examples of occult correspondence or sympathy—the ability of the heliotrope or sunflower to follow the sun across the sky, for example, or the mysterious and invisible connections that drew the vulture to distant carrion. Those Jesuits who addressed the weapon salve focused, too, on questions of ontology—was its action natural, or even supernatural?—and finally defined in strict terms which kinds of occult activity were "natural" and which were not. There was no room for ambiguity in their treatment of the salve, no ontological gray areas, and at least in the case of the weapon salve they managed to surmount the difficulties that had stymied Del Rio decades earlier.

Demonology and Del Rio

Demonology was arguably the most widespread means of investigating the hidden forces of nature in the fifteenth and sixteenth centuries. Pointing to demons and devils as the cause for effects produced by secret and occult means assured demonologists that they at least knew what that cause was—not perfectly, perhaps, but it was better than not knowing at all.[1] This focus on occult causes and on phenomena that were often difficult to explain meant that demonology was concerned primarily with the study of the preternatural, and like all such inquiry in this period it ran up against not only the ontological instability of the category itself but also the wider epistemological problems that accompanied the study of nature's mysterious and hidden forces.[2]

Those problems were magnified in cases of suspected demonic or diabolical activity because the consequences of this activity were cultural and theological as well as academic. Demons, and even the Devil himself, could not violate natural laws—only God could supersede nature altogether—but while constrained

[1] Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Oxford University Press, 1997), p. 160.

[2] Clark, *Thinking with Demons*, p. 171.

by these laws demons were generally thought capable of manipulating nature with far greater ease and facility than any human, to the point that they could produce effects that seemed wondrous or even miraculous. Just as the ranks of "the vulgar," ignorant as they were of nature's operations, might confuse a natural-but-extraordinary event with a genuine miracle, so too might they be tricked into seeing miracles where there was, in fact, only the handiwork of the Devil. This was a serious problem, for venerating such diabolical works could lead the ignorant into heresy and thence to eternal damnation.

Instances that had no obvious explanation, such as the sudden sickening of livestock or people, hailstorms that destroyed crops and property, and a host of other afflictions suffered by early modern people, were suspect precisely because their causes were unknown. When demonologists, jurists, and philosophers attempted to explain these instances, however, they ran up against a seemingly insuperable problem. A destructive storm could be entirely natural and caused without any external intervention, but it could also be a divine punishment for sin, or the vengeful act of a witch whose meteorological tampering was guided by a demonic hand. In each case, the *direct* or *proximate* cause was natural; the same forces collaborated to produce the storm whether those forces were guided by divine will, an act of witchcraft, or a natural accident. If the proximate cause of the storm was always the same, however, how was a jurist or philosopher to know whether there was another, more primary cause operating in the background?

What faced those with an interest in demonology, then, was a series of epistemological problems that not only made systematic investigation extremely difficult, but also made simple agreement among early modern thinkers all but impossible. As but one example, consider the physician Albert Kyper (1614–1655), who assured readers of his *Institutiones physicae* that "many things are done in this world by the force of demons which we in our ignorance attribute to natural causes."[3] Some thirty years later, John Webster (1610–1682) inveighed against this sort of thinking in his *Displaying of supposed witchcraft* when he cautioned, "There is nothing that doth more clearly manifest our scanted knowledge in the secret operations of nature ... than the late discoveries ... brought dayly to light by the pains and labours of industrious persons." He went on to argue, "Hitherto we have been ignorant of almost all the true causes of things, and therefore through blindness have usually attributed those things to the operations of Cacodemons that were truely wrought by nature."[4]

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[3] Clark, *Thinking with Demons*, p. 233.

[4] John Webster, *The displaying of supposed witchcraft* (London, 1677), pp. 267–8.

Thus, uncertainty and confusion confronted Martín del Rio when he decided to write his *Disquisitionum magicarum libri sex*. After compiling it steadily for some time, Del Rio had it published in 1599; it remained in print for almost 150 years, going through at least 24 editions before its final reprinting appeared in Venice in 1747. Del Rio himself already had a career as a jurist before he entered the Society of Jesus in 1580, and he distinguished himself sufficiently to merit praise from the Flemish humanist Justus Lipsius (1547–1606) who called him "the miracle of the age." After 1600, and for decades after his death, he was cited frequently as an authority on witchcraft, heresy, and magic.[5]

It makes sense to view the *Disquisitionum magicarum* as a weapon that Del Rio and others hoped would combat the forces of darkness that were thought to be spreading across Europe.[6] The study of magic was necessary because magic itself was dangerous; the deliberate manipulation of secret virtues or forces could lead all too easily to seduction by demons or other evil spirits, and thence to heresy. Del Rio conceded in the first pages of the treatise that the "most powerful and wise" properly called the investigation and manipulation of nature's secrets "magic," but the vulgar substituted evil superstition for this kind of wisdom. "This disease, on account of the desire for knowledge inborn to men, in a short time has spread itself throughout the entire world," he claimed,[7] and later he argued that, just as the corruption of bodily humors produces disease, so does the perversion of scriptural readings and magical arts produce heresy.[8] Del Rio pointed to a wide range of authorities to substantiate his claim that "heretics always hold extensive traffic with magic," before reminding his readers that it was the duty of the Society of Jesus "[to] oppose strenuously these many heretics."[9] Thus, if superstition was the root of heresy, then magic, so little understood by the uninitiated, too often acted as the root of superstition.[10]

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[5] For more on Del Rio and his relationship to skepticism, see Jan Machielsen, "Thinking with Montaigne: Evidence, Scepticism, and Meaning in Early Modern Demonology," *French History*, vol. 25, no. 4 (2011), pp. 427–52. For contemporary views on Del Rio and the *Disquisitionum*, see the brief biography produced shortly after his death by the Dutch Jesuit Heribert Rosweyde (1569–1629): *Martini Antonii Del Rio Brevi Commentariolo Expressa* (Antwerp, 1609).

[6] Martín del Rio, *Investigations into Magic*, ed. and trans. by P.G. Maxwell-Stuart (Manchester: Manchester University Press, 2000).

[7] Martín Antonio del Rio, *Disquisitionum magicarum libri sex, in tres tomos partiti* (Louvain, 1599–1600), *Epistola*, p. ii.

[8] Del Rio, *Proloquium*, pp. 6–7.

[9] Del Rio, pp. 4, 5.

[10] Many of these concerns overlapped with contemporary ideas about witchcraft; for more, see Lyndal Roper, *Oedipus and the Devil: Witchcraft, Sexuality, and Religion in Early*

The social and theological threats posed by the practice of magic were not an idle concern for the inquisitors, confessors, and jurists on the front lines of the Catholic Church's struggle against the forces of heresy and diabolism. Terrifyingly, they were fumbling in the dark, forced to work from the slightest of hints, the most tenuous of suppositions in their efforts to determine when and where the Devil was at work. This explains, at least in part, the lengths to which many of them were willing to go. Del Rio himself did not shy away from judicial torture when he deemed it warranted, though he advised readers of his *Disquisitionum magicarum*, when dealing with those younger than fourteen years, that "they are only to be frightened, although with real fright, that is, by being naked, bound, and led to the rack, but not however placed thereupon."[11]

The stakes, then, were enormously high. Del Rio needed a means of identifying the hidden causes behind suspected acts of magic, but he ran up against the same epistemological problems confronted by other early modern thinkers with an interest in studying the occult or insensible causes of particular phenomena. The inquisitor had to begin with the available evidence—typically accounts of what witnesses had seen and experienced—while contending with the stark reality of sensual fallibility. Not only are our senses inherently limited, but it was also widely believed that a demon could trick and manipulate the senses of witnesses, making even probabilistic conclusions suspect.

Del Rio turned to ontology as a means of distinguishing different kinds of causes from one another. He started by dividing magic into two kinds based on their causes, whether efficient or final—that is, based on either the means whereby magic worked, or the end or goal of the magical act. That which was determined by efficient causes "can be thought as divided [further] into *Natural*, *Artificial*, or *Diabolical*, all of the effects of which should be ascribed either to the innate things of nature, or to human industry, or to the wickedness of demons."[12]

Modern Europe (1994); J.A. Sharpe, *Instruments of Darkness: Witchcraft in Early Modern England* (Philadelphia: University of Pennsylvania Press, 1996); Jonathan Barry, Marianne Hester, and Gareth Roberts, eds., *Witchcraft in Early Modern Europe: Studies in Culture and Belief* (Cambridge: Cambridge University Press, 1998); Walter Stephens, *Demon Lovers: Witchcraft, Sex, and the Crisis of Belief* (Chicago: University of Chicago Press, 2002); Charles Zika, *Exorcising Our Demons: Magic, Witchcraft, and Visual Culture in Early Modern Europe* (Leiden: Brill, 2003).

[11] Del Rio, vol. III, p. 65: "Puto si sint minores annis XIIII tantum esse terrendos, etiam terrore reali; ut nudando, ligando, & ad eculeum adducendo, non tamen imponendo."

[12] Del Rio, vol. I, p. 3: "Tam latè sumptae Magicae, divisio petenda ex causis, finali & efficiente. *Ab efficiente* ducitur divisio in *Naturalem, Artificiosam & Diabolicam*, quia cuncta effectus eius ascribendi sunt vel insitae rebus naturae, vel humane industrie, vel cacodaemonis malitiae."

These three types of magic all involved the intentional manipulation of natural forces, but what was important was how those forces were manipulated. Purely natural magic, for example, might involve the harnessing of celestial or astrological correspondences to treat illnesses; as Del Rio described it, "Natural or legitimate magic was first given to Adam by God ... [and] is nothing other than a more exact knowledge of the secrets of nature, of the course and flux of the heavens and the stars, and the observation of the sympathy and antipathy of things, and the application of these things in the proper time, place, and manner, and through this pact or joining or application is produced wondrous things, which, to those ignorant of causes, appears to be trickery or miracles."[13]

In artificial magic, nature's unseen forces and virtues were manipulated by artifice or technology, as in a machine powered by the mysterious natural power of the magnet, while in demonic or diabolical magic individuals called on demons or devils to manipulate these forces. Of the three kinds of magic, this last one did not necessarily demand that one be a learned or skilled practitioner; an illiterate witch could call on demonic aid in committing acts of *maleficia* without understanding the forces at work. In a sense, this made demonic magic even more dangerous, for the demon itself was preternaturally skilled at working magic and was not constrained by the limitations of conscience, knowledge, or ingenuity that may have limited the workings of other, human magicians.

Magic that was determined by its final causes touched on the question of intention, that is, whether the magic had good or maleficent intent. Good magic worked through licit means, either natural or artificial, while maleficent magic depended upon prohibited works such as idolatry, superstition, and commerce with demons. In the uncertain world of demonology, it was often intention that provided hints as to whether a particular act or effect was good or bad. The task of the inquisitor, then, often became sifting through contextual clues to determine the effect of the magical act and whether one could posit intention from those clues.

Attempts to establish the motivation behind particular acts of magic were important, because a reader of Del Rio's *Disquisitionum magicarum* would soon understand that the philosophical study of causes themselves was all but useless in the investigation of suspected acts of magic. Consider, for example,

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[13] Del Rio, vol. I, p. 7: "Naturalem vero legitimamque Magicen [Magicam?] cum ceteris scientiis Adamo Deus largitus, a quo posteritas docta, per manus & orbem eam propagavit. Ea nihil est aliud quam exactior quaedam arcanorum naturae cognitio, qua caelorum ac siderem cursu & influxu, & sympathiis atque antipathiis rerum singularum observatis, suo tempore, loco ac modo res rebus applicantur, & mirifica quaedam hoc pacto perficiuntur, quae causarum ignaris praestigiosa vel miraculosa videntur."

the following inquiry posed by Del Rio: "By what signs can one distinguish the effects of magic which are dependent on a [demonic] pact, from effects that are physical, miraculous, and artificial?"[14] It was a simple enough question, and a vital one for any investigator, yet Del Rio's answer was murky at best. He told his readers that, if one cannot find evidence of a miracle, a purely natural act, or an example of artificial trickery—assuming that one could identify any of these things, itself enormously problematic—then a pact has occurred.[15] Del Rio tried to clarify his position by advising his readers that other clues, such as whether the operator of the magical effect used certain words or signs or relied on superstitious practices, should arouse suspicion. If such clues were absent, one could conclude that the effect was natural, but Del Rio then soberly reminded his readers of both Satan's power to deceive and our own ignorance of many things in nature.[16]

So in the end, answering as fundamental a question as "Is this particular effect the result of a demonic pact?" was fraught with tremendous difficulty. The inquisitor found himself relying on indirect clues rather than on any systematic or reasoned analysis of causes, and because these clues often emerged in accusations that were themselves part of complex social dynamics between individuals, they were far from the most reliable indicators of illicit magic.[17] Thus, even in so high-stakes a study of occult causes as demonology, concrete answers were few and far between.

Given Del Rio's struggles with basic ontology in the identification of causes, we might expect him to face similar struggles with the category of the preternatural. In fact, while he acknowledged its existence, Del Rio seemed eager to impose at least some measure of clarity on a work already beset by confusion and proposed an ontology that ultimately ignored the preternatural. He began by identifying what he called " the prodigious order" or the order of marvels, as distinct from *ordo gratiae seu miraculosus*, the order of grace or miracles, and noted that such marvels exist within the natural order but "are said to exceed by reason of the means [that is, the effect exceeds the ordinary means of the agent in

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[14] Del Rio, vol. I, p. 79: "Quibus indiciis discernendi effectus magiae ex pacto [convenio?], ab effectus Physicis, & miraculosis, & artificiosis?"

[15] As but one example, consider the problems faced by those who tried to prove seventeenth-century miracles as discussed in Peter Dear, "Miracles, Experiments, and the Ordinary Course of Nature," *Isis*, vol. 81 (1990), pp. 663–83.

[16] Del Rio, vol. I, pp. 79–80.

[17] There are many studies of the social contexts of early modern witchcraft; one of the most illuminating continues to be Alan Macfarlane, *Witchcraft in Tudor and Stuart England: A Regional and Comparative Study* (New York: Routledge, 1970; 2nd edn 2008).

question], so that either all men, or many of them, are ignorant of them" (*dicitur excedere ratione modi, quem vel omnes homines vel plerique ignorant*). He went on to assert that this "order of marvels" should more properly be called the *ordo praeternaturalis* and concerned "the many wondrous operations performed by good or evil angels by means of local motion, or by the unexpected application of natural agents."[18] This meant that such marvels were natural rather than supernatural, despite the inevitable fact that some interpreted such prodigies as miracles. Del Rio went further, however, in allowing his readers to dispense with this *ordo praeternaturalis* altogether: "Thus God established three orders: natural, miraculous, and prodigious, or, if you prefer, natural and supernatural."[19] Because prodigious or preternatural effects were, by definition, also natural effects, he saw no need for a separate category.

Earlier, I suggested that Del Rio failed to impose ontological clarity on the subjects of the *Disquisitionum magicarum*. In an important sense, this was true: his attempts to define an ontology that could distinguish between the insensible causes of magical effects were stymied by the myriad uncertainties that characterized early modern demonology. At the same time, however, Del Rio's willingness to leave the prodigious or preternatural to one side and contemplate instead a simple dualism—natural and supernatural—suggests that ontological clarity was precisely what he sought. The problems that pervaded this work were glaring, if straightforward: a fear that the uninitiated or ignorant might confuse natural for supernatural, or vice versa, and thereby expose themselves to heresy or other forms of diabolical interference. The solution to that was a means of clarifying and demonstrating the order of things.

The larger war on nature's secrets waged by certain Jesuits was also a quest for ontological clarity, an attempt to reduce the rather cluttered ontology handed down from medieval scholasticism to the same kind of simple dualism proposed by Del Rio. If his *Disquisitionum magicarum* was indicative of how thinkers around 1600 tried to classify and understand occult causes, however, we can see why those who came after Del Rio moved their inquiries away from the fraught, confusing realm of demonology and into the world of early modern natural philosophy. There, at least, they could more easily build a new ontology of the unseen, and the mysterious healing power of the weapon salve offered them a chance to do exactly that.

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[18] Del Rio, vol. I, p. 76: "ordo *praeternaturalis*, ad quem referuntur multae mirificae operationes factae per bonos vel malos angelos motu locali, vel subita naturalium agentium applicatione."

[19] Del Rio, vol. I, p. 76: "Tres ergo Deus ordines statuit, naturalem, miraculosum, & prodigiosum; seu, si duos malis, naturalem & supernaturalem."

Of Moss and Magnetism: The Weapon Salve[20]

When the English physician Walter Charleton (1619–1707) proclaimed in 1654 the "downright Inefficacy and Unsuccessfulness as well of the Armary Unguent, as the Sympathetick Powder," he was forced to confess that "this Verdict, I presume, was little expected from *Me*, who have, not many years past, publickly declared my self to be of a *Contrary* judgment; written profestly in Defence of the cure of wounds, at distance, by the Magnetick, or Sympathetick Magick of the Weapon-Salve."[21] Indeed, his published defense of the weapon salve or "armary unguent" in his earlier *Ternary of Paradoxes* had been as vehement in its support for this marvelous medical remedy as was the repudiation that followed only four years later. In the *Ternary*, Charleton had devoted more than two dozen pages to a rousing and undoubtedly fictitious story in which he described converting a skeptical clergyman into an ardent supporter of the salve's marvelous efficacy.[22] Throughout, he composed paeans to the power of direct experience, which alone could uncover the light of Nature and which had convinced Charleton himself that the salve truly could heal wounds over distances, but as he admitted in 1654, it was only after undertaking a series of "frequent Experiments" that he had come to see the salve as fraudulent.

Charleton's change of heart is not altogether easy to understand; why should we believe that he was convinced of the salve's falsity by the power of experiment when it was yet another experiment that had been instrumental originally in convincing him of its efficacy? Perhaps he was simply easily swayed. His earlier *Ternary of Paradoxes* had been inspired by the work of the Flemish physician Jan Baptista van Helmont (1580–1644), who had published a controversial defense of the weapon salve decades earlier; Charleton's *Physiologia* of 1654, on the other hand, was a loose translation of the work of the atomist and mechanical philosopher Pierre Gassendi (1592–1655), an implacable enemy of occult qualities and of the philosophy of Aristotle, and someone who had already dismissed tales of the weapon salve's supposed power. There is ample evidence of Charleton's penchant for borrowing ideas from a range of sources, and it is

[20] Portions of this section appeared previously in Mark A. Waddell, "The Perversion of Nature: Johannes Baptista van Helmont, the Society of Jesus, and the Magnetic Cure of Wounds," *Canadian Journal of History/Annales canadiennes d'histoire*, vol. 38 (2003), pp. 179–97, and are reproduced with permission.

[21] Walter Charleton, *Physiologia Epicuro-Gassendo-Charltoniana* (London, 1654), pp. 381–2.

[22] Walter Charleton, *A Ternary of Paradoxes: The Magnetick Cure of Wounds; Nativity of Tartar in Wine; Image of God in Man* (London, 1650).

possible that his exposure to French philosophy, particularly that of Descartes and Gassendi, may have altered Charleton's ideas about occult phenomena in general and the weapon salve in particular between 1650 and 1654.[23]

Whatever Charleton's motivations, it is clear that in the decades on either side of the turn of the seventeenth century, the weapon salve became a central character in the ever-shifting body of phenomena that worked by mysterious and insensible means, its efficacy debated endlessly by philosophers, theologians, and physicians. Reputed to heal distant wounds quickly and cleanly when applied to the weapon or instrument that had caused them, or to traces of blood from the wounded patient, the salve attracted as much censure as it did praise. These debates reveal many of the preoccupations and anxieties that drove the investigation of the unseen in this period, particularly how to distinguish different kinds of occult causes from one another. This was certainly true for those Jesuits who addressed the problem of the weapon salve: they used its reputed properties both to define the ontological boundaries between different examples of occult causation and to establish their own prerogative to make such definitions.

Before we examine the complex interplay between the Society of Jesus and the salve in the seventeenth century, we first need to understand both what the salve was and what role it played in the intellectual life of the period. In the most general terms, the salve enjoyed a long and contentious history as a topic of philosophical discussion, making its first appearance in the late sixteenth century but surviving, in one form or another, well into the eighteenth century. And yet, in spite of its long history and the fascination it engendered, the weapon salve has almost never been taken seriously in the modern era. The positivist thinkers of the late nineteenth century dismissed it as an intellectual aberration, a piece of overwrought superstition fomented by the seemingly infinite credulity of earlier times.[24] Somewhat surprisingly, the more nuanced and contextualized sensibilities of today's historians have been scarcely less dismissive. More often than not, the salve remains a curiosity, a marker of strange and curious early modern beliefs rather than a topic of serious philosophical disagreement. Because it inspired such controversy in its day, however, the salve was able—for

[23] Eric Lewis, "Walter Charleton and Early Modern Eclecticism," *Journal of the History of Ideas* 62 (2001), pp. 651–64; L. Sharp, "Walter Charleton's Early Life 1620–1659, and Relationship to Natural Philosophy in Mid-Seventeenth Century England," *Annals of Science* 30 (1973), pp. 311–40.

[24] One interesting example is the unfinished work by the prominent nineteenth-century physician Sir William Osler: *Sir Kenelm Digby's Powder of Sympathy: An Unfinished Essay* (Los Angeles: Plantin Press, 1972).

a time, at least—to shape discussions about the insensible powers of nature in a way that was simultaneously more public and more powerful than almost any other example of occult causation.

The salve, or substances like it, carried many names. In Latin, it was the *unguentum armarium* (translated literally in some English texts, such as Charleton's *Physiologia*, as "the armary unguent"); others called it the c*ura magnetica* or the *unguentum magneticum*—the magnetic cure or unguent, pointing to the frequent comparisons drawn between the activity of the salve and that of the lodestone or magnet. From the early decades of the seventeenth century it was more often known as the "powder of sympathy" or, in French, the *poudre sympathique*. This lack of etymological consensus mirrored an almost total lack of agreement as to how the salve worked, and even what its ingredients were. Because everyone agreed that this substance—whatever it was called—was reputed to heal wounds quickly, cleanly, and painlessly even over distances of several miles when applied to a weapon or to traces of blood, I will simplify matters by gathering these disparate remedies beneath the convenient umbrella of a single term: namely, "the weapon salve."

Though the salve eventually made its way into some aspects of seventeenth-century popular culture—for example, appearing in more than one play as a satirical device highlighting the ineptitude and astonishing credulity of the intellectual elite—its exact origins were a subject of mystery in early modern culture, and largely remain so today.[25] Many people attributed it to the itinerant physician-mystic Paracelsus (1493–1541), and though some modern historians have found references to the salve in the writings of Paracelsus, others claim that this attribution is false and derived from pseudo-Paracelsian texts.[26] Of course, Paracelsus was not the only possibility for early modern thinkers: witness the characteristically extravagant claim made by Kenelm Digby (1603–1665), who

[25] William Bynum, "The Weapon Salve in Seventeenth-Century English Drama," *Journal of the History of Medicine and Allied Sciences*, vol. 21 (1966), pp. 8–23; Paul G. Brewster, "Physician and Surgeon as Depicted in 16th and 17th Century English Literature," *Osiris*, vol. 14 (1962), pp. 13–32.

[26] For examples of those who claim to have located the salve in the Paracelsian literature, see Carlos Ziller Camenietzki, "Jesuits and Alchemy in the Early Seventeenth Century: Father Johannes Roberti and the Weapon-Salve Controversy," *Ambix*, vol. 48, no. 2 (2001), pp. 83–4, and Daniel Stolzenberg, "The Sympathetic Cure of Wounds: A Study of Magic, Nature and Experience in Seventeenth-Century Science," M.A. Thesis, Indiana University (1998), p. 3. For the pseudo-Paracelsian interpretation, see Walter Pagel, *Joan Baptista van Helmont: Reformer of Science and Medicine* (Cambridge: Cambridge University Press, 1982), p. 9. For a comprehensive history of the salve, see Roberto Poma, *Magie et guérison: La rationalité de la medicine magique, XVIe—XVIIe* (Paris: Orizons, 2009).

told friends and acquaintances that he had introduced the sympathetic treatment of wounds to Europe all by himself after learning its secrets from a Carmelite friar who himself had been taught by a wandering Oriental mystic in the Far East.[27] Descriptions of the curing of wounds over distances had appeared decades before Digby himself, of course, but by the time Digby's claims appeared in English this hardly seemed to matter to his contemporaries; their apparent fascination with the topic encouraged twenty-nine subsequent editions of his *Discourse on the Sympathetick Powder*, the last of which appeared in France in 1749.[28]

If we exclude the contested Paracelsian sources, one of the earliest references to the weapon salve appeared towards the end of the sixteenth century in a later edition of the influential *Magia naturalis* of Giambattista della Porta (1535?–1615). Placing the salve alongside remedies for toothache and a description of "the virtues of tobacco," Della Porta briefly described its properties and attributed it to Paracelsus, who reportedly gave it to the Holy Roman Emperor Maximilian.[29] Della Porta's book was published several times in both Latin and vernacular editions, disseminating the idea of the weapon salve to a wide audience.[30] Other influential publications soon began discussing the weapon salve as a topic of medical and natural philosophical interest. In 1608, the physician and chymical philosopher Oswald Croll (1560–1609) published a largely Paracelsian treatise, his *Basilica chymica*, in which he devoted several pages to the preparation and application of the weapon salve, again attributing it to Paracelsus and couching much of his discussion in astrological language.[31] Croll also included an easy-to-follow recipe for preparation of the salve, recommending not only *usnea* (moss or lichen) scraped from a human skull and *mumia* (remnants, usually preserved, of human flesh and blood), but also bear or boar fat, dried boar's brains, powdered

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[27] Sir Kenelm Digby, *Of the Sympathetick Powder: A Discourse in a Solemn Assembly at Montpellier, Made in French … 1657* (London: John Williams, 1669).

[28] On Digby's mendacity, see Elizabeth Hedrick, "Romancing the Salve: Sir Kenelm Digby and the Powder of Sympathy," *The British Journal for the History of Science*, vol. 41 (2008), pp. 161–85. On the many editions of Digby's work, see Stuart Clark, *Thinking with Demons*, p. 270; Lynn Thorndike, *A History of Magic and Experimental Science* (New York: Columbia University Press, 1923), vol. VII, p. 507.

[29] Giovanni Battista della Porta, *Magia naturalis libri XX* (Naples: Horatium Salvianum, 1589). In the English translation, *Natural Magick* (London: Thomas Young & Samuel Speed, 1658), the description of the weapon salve can be found in Book 8, pp. 228–9.

[30] Camenietzki, p. 84.

[31] Oswald Croll, *Basilica chymica philosophicam propriam laborum experientiam …* (Frankfurt: Godefirdi Tampachii, 1608). Croll's *Basilica chymica* was later translated into English by an anonymous "Lover of Chymistry" with the title, *Basilica chymica, & Praxis chymiatricae, or Royal and Practical Chymistry* (London: John Starkey, 1670).

maggots, and red sandalwood. *Usnea* and *mumia* (or, in English, "mummy") were relatively common ingredients in medicinal preparations; boar's brains and powdered maggots may have been more exotic.[32]

Thanks to widely-read authors like Della Porta and Croll, the weapon salve rapidly assumed greater visibility across Europe in the early years of the seventeenth century, a prominence that would persist for decades. Its increasingly controversial reputation reached its apex in 1660 with the publication in Nuremberg of the *Theatrum sympatheticum*, a collection of previously published works devoted to the salve. A pirated edition of the *Theatrum* appeared in 1661 and it was then much expanded in a second, licensed edition printed in 1662.[33] Both of the licensed editions were the work of Sylvester Rattray (fl. 1650–1666), a relative unknown whose interest in sympathies and antipathies was obvious in his own treatise that he appended to the beginning of the *Theatrum*. At more than 700 pages in length, the *Theatrum* provides an excellent demonstration of both the volume and complexity of thought devoted to the weapon salve in this period. Moreover, the popularity of the weapon salve did not wane entirely after 1662; Dutch editions of the *Theatrum* continued to appear around the close of the seventeenth century, while several theses defended by students at Harvard College in the first two decades of the eighteenth century focused specifically on the powder of sympathy.[34]

At first, the salve's supposed links to Paracelsus made it particularly controversial. The thoroughly anti-Paracelsian physician and chemist Andreas Libavius (1560–1616) argued specifically and vociferously against the weapon salve in his *Tractatus duo physici* (1594), claiming that the activity of the salve

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[32] The section devoted to the weapon salve in the English edition of Croll's *Basilica* is entitled, "The Sympathetick Oyntment, or Stellate of Paracelsus," and can be found on pp. 173–8.

[33] The two licensed editions were both printed by Johann Endter: *Theatrum sympatheticum, in quo sympathiae actiones variae, singulares & admirandae tam Macro quam Microcosmicae exhibe[n]tur …* (Nuremberg, 1660) and *Theatrum sympatheticum auctum, exhibens varios authores, de pulvere sympathetico …* (Nuremberg, 1662). The unlicensed edition was *Theatrum sympatheticum, in quo sympathiae actiones variae … exhibentur … Amstelaedami, Impensis Thomae Fontani* (Amsterdam, 1661).

[34] These Dutch editions were probably variations of the large 1662 edition, and included *Theatrum sympateticum, Ofte Wonder-Tooneel des Natuurs Verborgentheden* (Amsterdam: Jacob van Royen en Timotheus ten Hoorn, 1681), and an edition of the same title that was published by Johannes ten Hoorn in Amsterdam, 1697. For references to the Harvard defenses, see William Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Cambridge, MA, 2003), p. 35.

was unnatural and therefore diabolical in origin.[35] It is significant, however, that Libavius did not deny that the weapon salve might actually cure distant wounds; in fact, what concerned him was not whether it worked, but the agency by which it operated. This pattern persisted throughout the seventeenth century, with commentators on all sides of the debate focusing less on whether the salve worked and more on how it operated, which was itself a more interesting and important question, philosophically speaking. That the salve functioned as a testing-ground for competing ideas about different kinds of occult activity was only made possible by this tacit decision to question its agency rather than its apparent efficacy. This in turn provides us with a means of exploring the real significance of the weapon salve in early modern natural philosophy.

For the modern observer, what is striking about early modern discussions of the salve is the profusion of competing theories and claims advanced by those who discussed it. In itself, this mirrors a similar profusion of thoughts and ideas that was typical of the rise of the "new philosophies" in this period, but with perhaps one or two exceptions, modern historians have been reluctant to connect the debates that swirled around the weapon salve with the wider natural philosophical debates that were on the rise at the same time. Instead, the salve has more often been connected to contemporary theological differences, or to the somewhat marginalized realm of magical theory, rather than to fundamental issues in natural philosophy.[36] In fact, however, the salve evolved into a crucial locus for inquiry into distinctions between different kinds of insensible or invisible agency, transcending the more limited realms of theology or magic. That the salve functioned as such a locus, not just for the Jesuits but for others as well, provides the historian with a plausible explanation for the widespread and indisputable interest it stimulated in early modern thinkers of all philosophical camps.

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[35] Andreas Libavius, *Tractatus duo physici: prior de impostoria vulnerum per unguentum armarium sanatione Paracelsicis usitata commendataque* (Frankfurt: Joannes Saur, 1594). More information about Libavius can be found in Bruce T. Moran, *Andreas Libavius and the Transformation of Alchemy: Separating Chemical Cultures with Polemical Fires* (Sagamore Beach, MA: Science History Publications, 2007); Owen Hannaway, *The Chemists and the Word: The Didactic Origins of Chemistry* (Baltimore: Johns Hopkins University Press, 1975).

[36] See, for example, Camenietzki, p. 83; Stolzenberg, "The Sympathetic Cure of Wounds," p. 28.

The Salve on Trial

During his examination by ecclesiastical authorities in 1627, the Flemish physician and medical reformer Jan Baptista van Helmont made a startling claim that would transform his trial from a standard investigation of suspected heresy into the juiciest of courtroom dramas. Insisting that he was a pious and orthodox Catholic, Van Helmont told his examiners that he had been embroiled in controversy by a series of deliberate machinations engineered by a Jesuit named Jean Roberti (1569–1651). These machinations purportedly revolved around a single work, the *De magnetica vulnerum curatione*, or "On the magnetic healing of wounds,"[37] which Van Helmont claimed had been published without his permission after he sent a manuscript copy to Jean Roberti's brother in Paris.[38] The consequences for Van Helmont were disastrous. Thanks to an imprudent comparison between the weapon salve and the curative powers of holy relics, he found himself censured and repudiated by thinkers across Europe before being questioned by the Spanish Inquisition in 1627. His reputation in tatters, condemned by the Church for publishing heretical opinions, he was confined to his home near Vilvorde for a time, and though he continued to experiment and write up until his death in 1644, he did not discuss the weapon salve in detail again. He received a posthumous rehabilitation thanks to the efforts of his widow, and his medical works became truly influential, likewise, only after his death when they were published by his son.[39]

Why Jean Roberti should have involved himself in the publication of Van Helmont's work—if, indeed, he did so—is not difficult to understand. Roberti had been publishing refutations of the weapon salve for many years by the time Van Helmont penned a response, and the latter was not shy about throwing the occasional rhetorical jab at his opponent; for example, in describing the essential ingredient of *usnea* or moss scraped from a skull, Van Helmont urged his readers not to be too picky about the cranium in question: "For if a Jesuit, being put to death by hanging or another kind of martyrdom, is left in a position to receive

[37] Jan Baptista van Helmont, *De magnetica vulnerum curatione: Disputatio contra opinionem D. Joan. Roberti, presbyteri de Societate Jesu, Doctoris Theologi, in breve sua anatome sub censurae specie exaratam* (Paris: Le Roy, 1621).

[38] For more detail on the Van Helmont affair, see the collection of documents assembled by Corneille Broeckx in his *Interrogatoires du docteur J.B. van Helmont, sur le magnétisme animal, publiés pour la première fois par C. Broeckx … Extrait des Annales de l'Académie d'Archéologie de Belgique* (Anvers, 1856).

[39] Further details about Van Helmont's life can be found in Pagel, *Joan Baptista van Helmont*, as well as in Pagel's entry for Van Helmont in the *Dictionary of Scientific Biography*, vol. 6 (New York Charles Scribner's Sons, 1972), pp. 253–9.

the influence and obedience of the stars, his head, like the skull of a thief, will yield a crop of moss equivalent in utility, equally ripe ..."[40] Van Helmont also mocked the Society of Jesus, which, with obvious insincerity, he characterized as "so helpful to the whole world."[41] These were dangerous things for a man to write while living in the Low Countries, then under Spanish (and thus Catholic) control, and they almost certainly would have attracted Roberti's ire.

Another important factor in Van Helmont's public censure was the particularly thorny claim that the weapon salve could heal over distances without direct contact. This inspired a persistent correlation between the activity of the salve and that of the magnet, a correlation that Van Helmont himself supported. To talk about one phenomenon around the turn of the seventeenth century often meant to talk about the other. As a result, Jesuit discussions of the weapon salve came to focus on questions of definition and discrimination: how one could tell the difference between two things that seemed the same, but probably were not.

The frequent comparisons drawn between the magnet and salve throughout the early decades of the seventeenth century allowed the Jesuits to employ both phenomena as boundary-markers between a legitimate and natural example of invisible activity on the one hand, and a non-natural, illegitimate example of such activity on the other. Roberti and others pointed out that the properties of the magnet restricted its efficacy to a defined and limited distance while the efficacy of the salve was reputed to extend over virtually unlimited distances. Claims for this sort of unlimited agency endangered the ontological distinctions between the natural and the supernatural, between objects limited by the constraints of their materiality and those that were free to operate beyond those same constraints.

The Jesuits thus framed their repudiation of the weapon salve around a predominant interest in questions of ontology. In their hands, the salve became a means of defining what it meant for something to be "natural" and, by contrast, what it meant to be "not natural." From Roberti's reasoned and logical refutation of the physics behind the salve's reputed activity to Athanasius Kircher's blistering condemnation of the radical supernaturalism eventually used to explain the salve's operation, these members of the Society sought to reinforce the primacy of the supernatural and its crucial separation from the natural order. By focusing on so controversial a phenomenon, however, the Jesuits who discussed the salve also demonstrated to a growing audience their collective ability to recognize and proclaim different kinds of insensible agency in the world.

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[40] As republished in the posthumous *Ortus medicinae* (Amsterdam, 1648), p. 756.

[41] Van Helmont, *Ortus medicinae*, p. 759.

Roberti's published criticisms of Van Helmont's heterodox opinions focused precisely on the distinction between the magnet and the salve.[42] Van Helmont and other proponents of the salve such as Rudolph Goclenius the Younger (1572–1621) sought to legitimize the salve by casting it as a natural analogue to the magnet, while at the same time marveling at the salve's wondrous ability to operate over vast distances and to ignore physical impediments to its efficacy. In this case, comparisons with magnetism could lend credibility to a controversial phenomenon; to be like the magnet was, by definition, to be natural. By contrast, Roberti and another contemporary within the Society, Gaspar Wenckh (1589–1634), argued that the salve's agency could not be unlimited by concerns of distance or force, because no natural object—including the magnet—could produce an unlimited physical effect.[43] This, indeed, is a critical point: all of the Jesuit attacks on the weapon salve discussed here were based, first and foremost, in physics. In magnetism, or in related physical operations such as the propagation of light or heat, the strength of the effect was known to wane as distance from the source increased: a magnet could affect a piece of iron only very weakly if one was moved away from the other, and likewise, light dimmed and heat decreased the further one moved from the source. The salve, however, operated under no such constraints, at least according to most of its proponents, and the Jesuits took pains to frame their repudiation of this phenomenon as one rooted in Aristotelian physics.

Unsurprisingly, the exclusion of the salve from the realm of the natural was argued most forcefully by the two Jesuit experts on magnetism, Niccolò Cabeo and Athanasius Kircher. Roberti and Wenckh had already dismissed the idea that the salve could operate over vast distances while also being a properly natural substance, and had provided evidence confirming this as an impossibility. It fell to Cabeo and Kircher to reinforce the salve's difference from the magnet, to exclude it from the category of the natural and thereby to consign it to the ontological hinterlands. Once exiled there, the salve would cease to be a problem; it would no longer possess the ability to blur and disrupt that primary ontological distinction between the natural and the supernatural. It would remain a mystery, perhaps, but no longer a troublesome one.

Niccolò Cabeo has received relatively little attention from historians, though he was a well-known and respected philosopher in his own day. Born in Ferrara in 1586, he entered the Society of Jesus in 1602 at the age of sixteen, and eventually

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[42] Johannes Roberti, S.J., *Curationis magneticae, & unguenti armarii magica impostura, clarè demonstrata ... .Modesta responsio ad perniciosam disputationem Io. Baptistae ab Helmont Bruxellensis Medici Pyrotechnici ...* (Luxemberg: Hubertus Reuland, 1621).

[43] Gaspar Wenckh, S.J., *Notae unguenti magnetici et eiusdem actionis* (Dilinger, 1626).

died in Genoa in 1650. He taught philosophy, theology, and mathematics in the Society's schools, and Galileo once credited him with exciting his interest in the physics of falling bodies.[44] During Cabeo's lifetime he was known primarily as an expert on magnetism, and in the fourth book of his *Philosophia magnetica* (1629) he devoted some five pages to a chapter entitled, "It is fictitious, that two men should be able almost to speak to one another from most remote and secret places, by means of the shared direction of two compasses."[45] What followed this somewhat mystifying statement, however, was an extended disquisition on sympathy and antipathy in which he questioned, among other things, the nature and activity *de unguento illo Armario*, "of that armary unguent"—the weapon salve.[46]

Cabeo described a fictitious experiment in which two individuals communicated with one another by means of simple devices, both made from iron mined from the same vein, inscribed with the letters of the alphabet, and fitted with an iron needle in the style of a compass. By applying a magnet to one device, an individual could supposedly induce an identical and sympathetic effect in the corresponding device even if it was many miles away, permitting communication over vast distances as the needle swung from one letter to the next. Cabeo argued that such a feat was impossible, pointing out that "all physical agents delimit for themselves a sphere of activity, beyond which they cannot act."[47] He then expanded this thinking to the weapon salve and to the "imaginary sympathy" proposed by supporters of the salve to explain its wondrous efficacy, noting that if he were to hold a compass in Italy, it would not be affected by a magnet in Spain, but that proponents of the salve's efficacy were willing to believe that it could and did act over such vast distances all the time.[48]

Thus, Cabeo articulated a careful comparison between the behavior of the magnet, which he demonstrated himself using experimental trials, and the reputed behavior of the weapon salve. His conclusion was simple: whatever the salve was, it did not behave like a natural agent such as the magnet, and so could not be natural. Unlike Jean Roberti, however, Cabeo did not argue for the single

[44] For biographical information on Cabeo, see the *Bibliothèque de la Compagnie de Jésus*, Carlos Sommervogel, S.J., ed., volume II (1991), p. 483; also, Attilio Frajese's entry, "Cabeo, Niccolo," in the *Dictionary of Scientific Biography*, vol. 3 (New York: Charles Scribner's Sons, 1980), p. 3.

[45] Niccolò Cabeo, S.J., *Philosophia magnetica* (Cologne, 1629), p. 301: "Fabulosum est, quod duo Homines possint quasi se alloqui è remotissimis, & clausis locis, per duorum versoriorum mutuam directionem."

[46] Cabeo, p. 304.

[47] Cabeo, p. 303: "omnia autem agentia physica determinant sibi sphaeram activitatis, ultra quam agere non possunt ... "

[48] Cabeo, p. 305.

possibility of diabolical or demonic intervention. He suggested instead that the wound might be healed by "nature alone," particularly if it were bathed often in wine because "the tartar in wine heals best."[49] Therefore, the salve was not the agent responsible for curing the wound, or, if it was involved at all, it cured merely accidentally. For example, if an individual followed the directions for using the salve as described in Oswald Croll's *Basilica chymica*, which counseled daily changing of the patient's bandages and washing the wound in urine or wine, then the use of the salve, according to Cabeo, only accidentally aided in the natural healing of the wound. In either case, the salve itself was not the direct cause of the curative effect, and was thereby deprived of any real agency.[50]

The other Jesuit to articulate an argument repudiating the weapon salve was Cabeo's younger contemporary Athanasius Kircher, who has achieved more notoriety among historians than Cabeo himself. We know, for example, that Kircher's life before he reached Rome was marked by a series of near-disasters; as a child he was almost crushed by a water mill—more than once—and, as an adult, he was captured and beaten by Protestant mercenaries before finding himself floating downriver on an ice floe.[51] Entering the Society of Jesus in 1618 at the age of sixteen, the constant warfare then plaguing Germany displaced him repeatedly over the next several years, and he later decided that his improbable survival, after enduring the hostile attentions of the Protestants who had captured him while he fled their advancing army, was a clear case of divine providence. After he settled in Rome, Kircher made repeated requests that he be allowed to leave and travel abroad, all of which were denied by his superiors. Instead, he remained in Rome for the rest of his life, founding his famed museum at the Collegio Romano, producing more than thirty published works, and establishing an extensive network of correspondents both within and beyond the Society of Jesus.

Like Cabeo, Kircher articulated his own refutation of the salve in his best-known work on the magnet, the *Magnes*; *sive, De arte magnetica* (1641). More specifically, he chose to do so in opposition to the radical supernaturalism of

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[49] Cabeo, p. 304. His suggestion here echoes the advice proffered in a tract attributed (perhaps erroneously) to the physician Daniel Sennert (1572–1637), *The weapon-salves maladie, or, A declaration of its insufficiencie to performe what is attributed to it*.

[50] The English translation of Oswald Croll's *Basilica chymica*, the *Royal and Practical Chymistry* (1670), notes on p. 178 that cleaning and binding the wound will aid in the "consolidation" or healing of the injury, but that the effects of doing so are limited, and could not produce the speedy recovery witnessed in cases where the salve was employed.

[51] Ingrid Rowland, *The Ecstatic Journey: Athanasius Kircher in Baroque Rome* (Chicago: University of Chicago Library, 2000), p. 3.

the English physician and occult philosopher Robert Fludd (1574–1637). That Fludd had died some four years before the *Magnes* appeared in print and was thus unlikely to pen a response presumably made Kircher's task rather easier. His refutation of the salve operated simultaneously on two distinct but related levels, philosophical and theological, perhaps as a counter to Fludd's avowed creation of a "theophilosophy" that combined Neoplatonic and hermetic philosophy with scriptural exegesis.[52] Kircher focused on two main points in his refutation of Fludd's defense of the salve: the first echoed Cabeo's earlier physical objections and highlighted the seeming impossibility that a substance could effect material changes over vast distances and through intervening objects, while the second addressed Fludd's supernaturalism. Kircher's treatment of the salve in these few pages of his *Magnes* explicitly excluded this phenomenon from both the direct and supernatural agency of God and the natural agency of objects like the magnet. He sought, in other words, to repudiate a controversial phenomenon that threatened to obscure basic and widely accepted ontological boundaries.

In a direct attack on Fludd's "theophilosophy," the first thing that Kircher stated in his third and final book of the *Magnes* was that "the will of God is not the immediate cause of an occult force."[53] Moreover, he went on to add that "God does not desire us to be ignorant of the powers of things," suggesting that the Creator actively encouraged the search for occult forces in nature and their causes, or more importantly, made the manifestations of those forces obvious so we might better study them.[54] When Kircher reached his direct repudiation of the salve, he identified the focus of his attack only as *au[c]tor Philosophiae Mosaicae*, "author of the Mosaicall Philosophy"; this was Fludd, whose *Philosophia Moysaica* first appeared in 1638 and was later translated as the *Mosaicall Philosophy* in 1659. Kircher began by noting that the salve reputedly operated over "a distance of indeterminate length." He then summarized Fludd's thoughts on activity in the world: "There is no effect that proceeds from a natural agent, but [it rather proceeds from] that most central Divine Spirit, which, as [stated] in Genesis ... works all things in all things."[55] Kircher also presented Fludd's claim that "all meteorological effects are not produced by the collusion of the elements, but by the immediate action of God, through angels," before stating emphatically that this idea was both impious and blasphemous.[56]

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[52] For more on Fludd and his ideas, see William Huffman, *Robert Fludd and the End of the Renaissance* (New York: Routledge, 1988).

[53] Athanasius Kircher, S.J., *Magnes; sive, De arte magnetica*, 1st ed. (Rome, 1641), p. 528.

[54] Kircher, *Magnes* (1641), p. 530.

[55] Kircher, *Magnes* (1641), p. 778.

[56] Kircher, *Magnes* (1641), pp. 778, 779.

Fludd's reason for attributing ostensibly natural actions to the direct intervention of God, according to Kircher, was that he could then describe such actions without worrying about the existence of "their ends" or physical limits (*termina*), nor about the possibility of a "determinate sphere" possessed by physical agents because this divine spirit could act over an indeterminate distance. The consequences of this notion, Kircher emphasized, would threaten not only long-standing ideas about nature, but the entirety of philosophy itself, which would be unable to explain anything in nature by recourse to intelligible, natural effects.[57] Indeed, as Kircher pointed out, if Fludd's literal interpretation of divine omnipresence as evinced in his dictum *Deus operatur omnia in omnibus* ("it is God who works all things in all things") were true, that would make every single operation of nature a miraculous event, a view that Kircher characterized as an absurdity.[58]

To resolve the question of whether the salve operated naturally, Kircher posed what he saw as the critical question: "Whether this unguent operates within a determined space, or an indeterminate one."[59] His concern could not be more explicit: the determination of the salve as a natural thing was dependent upon whether its agency could be shown to be limited, to act within a defined and determined space, or not. He also argued that "[t]he active force of all created agents is circumscribed by certain limits or ends."[60] Were it not so, were natural things able to act over an indeterminate distance, he argued that the world itself would come to an end, as the lethal stare of the Libyan basilisk or the poisonous breath of the African dragon would kill as far away as Germany, France, or England, for there would be no limits on how far such effects could reach.[61]

Kircher concluded that the salve "does not act naturally," in part because its activity changed depending on the direction in which it was applied to the sword and whether it was kept hot or cold. The magnet, held up by Kircher as exemplifying a natural if occult agency, worked the same way regardless of such concerns. He then emphasized that the salve "does not act *magnetically*" either, reiterating the same concerns already articulated by Cabeo. This fact rendered claims about the salve's efficacy "fallacious and suspect," because it could not operate as Fludd contended without violating the order of nature.[62] If the salve did actually heal distant wounds, its action could not be natural, and thus Kircher suggested that it must operate through some other, non-natural means,

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57 Kircher, *Magnes* (1641), pp. 778–9.
58 Kircher, *Magnes* (1641), p. 781.
59 Kircher, *Magnes* (1641), p. 780.
60 Kircher, *Magnes* (1641), p. 780.
61 Kircher, *Magnes* (1641), p. 780.
62 Kircher, *Magnes* (1641), p. 782.

either accidental or demonic—accidental if the cure was actually wrought by the sanative effects of wine or the patient's urine, or demonic if the practitioner entered into a communion with demons, wittingly or unwittingly.[63] These possibilities were the only ones Kircher was willing to consider in explaining the activity of the weapon salve, which he claimed was merely "pseudomagnetical" and did not operate by means of the occult magnetic forces he discussed throughout the *Magnes*.[64]

Ten years after Kircher used the weapon salve to repudiate Robert Fludd's radical supernaturalism, the Society of Jesus produced the *Ordinatio pro studiis superioribus*, which outlined the doctrines and ideas that members of the Society were forbidden to teach. Most prominent were doctrines that complicated physical explanations for the transubstantiation of the Eucharist, particularly atomism and Cartesian extension, but listed there as well was the weapon salve.[65] By this point, the salve had already started its slow decline as a topic of interest among early modern thinkers, but its inclusion in the *Ordinatio* is telling. Like a host of objects that worked by insensible or occult means, it had the potential to skew radically the fundamentals of physical activity as understood by early modern thinkers, even as it raised philosophical problems that transcended physics altogether.

There were serious consequences for the Aristotelian worldview raised by a confusion between different kinds of insensible agencies. Motivated by the Thomism at the core of the Society of Jesus, the Jesuits strove to eliminate this blurring of boundaries by excluding the salve from the two ontological categories it threatened. In itself, however, the act of exclusion—or, to put it somewhat differently, the exercise of deontology—reinforced those boundaries by demonstrating that they were, in fact, inviolable, whatever some thinkers mistakenly argued. The salve's reputed efficacy might appear to blur the lines between the natural and other categories, but every one of these Jesuits demonstrated clearly that this was an illusion, and a dangerous one at that, as Van Helmont discovered in full.

The weapon salve was not a problem merely for Aristotelian philosophers such as the Jesuits. There was hardly a thinker in the seventeenth century who did not address, at some point, the troublesome question of the salve's reputed

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[63] Kircher, *Magnes* (1641), p. 783.

[64] Kircher, *Magnes* (1641), p. 784.

[65] *Ordinatio pro studiis superioribus* (1651), p. 29: "Possunt fieri curationes vulnerum vel morborum per medicamenta applicata in distantia, seu per unguentum quod vocatur armarium."

efficacy.[66] This was certainly due in part to the fact that the salve's very identity as a natural object was open to debate. But it was also due to the serious questions that its existence raised: how might one study the effects of this phenomenon? Could they be established reliably? Were those effects comparable to those exhibited by other phenomena, like the magnet? If not, why? These questions were not limited to the weapon salve; eventually, they were asked of everything.

[66] This point is made with encyclopedic vigor by Poma's *Magie et guérison*.

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Chapter 3
The Demise of Occult Qualities

In his *Parhelia* of 1629, the French mechanical philosopher Pierre Gassendi proclaimed, "For me, undoubtedly, there is nothing that is not a magnet or a remora; for this reason, even the smallest animal of any kind, the smallest plant, the tiniest pebble, when I truly study it, astonishes me."[1] He opposed this ideology to that of the Aristotelians, who pretended to "see things from the inside" with their hylomorphic doctrine of form and matter but who, according to Gassendi, were unable to describe so much as the essence of a flea. There is a certain irony here, for almost four centuries earlier Thomas Aquinas (1225–1274), one of the greatest proponents of Aristotle in the Middle Ages, had admitted that "our cognition is so feeble that no philosopher has ever been able to investigate completely the nature of a fly."[2] Aquinas was concerned with the inherent limits of human understanding, circumscribed by the gross material of our bodies and but a frail shadow of the knowledge lost in humanity's original fall from grace. Gassendi, however, was exulting in a science of mechanism that had abandoned any claims to the demonstration of essences; our knowledge stops at "the bark of things," he argued, and anything beneath that bark would remain a mystery. Gassendi's advocate in England, Walter Charleton, echoed this sentiment when he wrote, "To Ourselves all the Operations of Nature are meer Secrets."[3]

While Gassendi, Charleton, and others seemed willing to accept this state of affairs, some of their contemporaries, Jesuits prominent among them, were not. Accordingly, in this chapter we examine this problem by focusing on the two objects singled out by Gassendi himself: the magnet and the remora. The former was, by the early decades of the seventeenth century, the subject of intense experimental scrutiny from thinkers across Europe; the remora, by contrast, was an enigma, a mysterious fish described in natural histories stretching back

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[1] Pierre Gassendi, *Opera Omnia*, vol. 3 (Lyon, 1658), p. 653: "Mihi certe nihil non magnes, ac remora est; ideo me vel minimum quodvis animalculum, minima plantula, minimus lapillus, dum serio contemplor, attonitum facit."

[2] Thomas Aquinas, *Collationes super Credo in Deum* (1273), *Praefatio*; as cited in Norman Kretzmann & Eleonore Stump, eds., *The Cambridge Companion to Aquinas* (Cambridge: Cambridge University Press, 1993), p. 143, n. 56.

[3] Walter Charleton, *Physiologia Epicuro-Gassendo-Charltoniana* (London, 1654), p. 341.

to antiquity.[4] For Gassendi, as for many early modern thinkers, they were both natural marvels because they possessed unusual properties: on the one hand, the magnet's ability to act on iron without physical contact, and on the other the remora's reputed power to halt ships by attaching itself to their hulls. Both, too, had long been consigned to the category of the preternatural because they were exemplars of occult or hidden activity in nature; there was nothing visible or manifest about these objects that hinted at their extraordinary properties.

For Aristotelians, objects that possessed occult properties were troublesome because their causes were hidden and thus impossible to know with certainty. One way in which the medieval scholastics had sought to make them intelligible was to codify the doctrine of occult qualities, which allowed them to separate those hidden properties from other, manifest qualities. In the case of the magnet, this meant that the Aristotelian philosopher could inquire into its nature with reference to those qualities that were manifest to observation, but could only catalogue as "hidden," or *occultae*, those properties of the magnet that had no discernible link to observable qualities such as coldness and dryness. In practice, however, when confronted by insensible qualities or virtues medieval scholastics had tended to categorize their related phenomena as either metaphysical or, in some cases, unintelligible.[5] This is why Aquinas claimed that the cause behind the magnet's behavior was beyond human comprehension, a pessimism that would persist for centuries among proponents of Aristotelianism.[6]

Occult qualities remained fundamental to the Peripatetic philosophy well into the seventeenth century, but this did not stop several Jesuit authors from writing openly and explicitly about abandoning this doctrine, a fact that deserves attention. In their discussions of the weapon salve certain Jesuits had been concerned primarily with questions of ontology, sorting one kind of occult cause from another, and their conclusions would have been uncontroversial for most of their Aristotelian contemporaries. Here, in their attack on occult qualities, these and other Jesuits proposed something more radical: a novel epistemology, a new way of knowing and studying hidden causes and properties. In part, they accomplished this by denying that some occult qualities existed at all, transforming

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[4] Brian Copenhaver, "A Tale of Two Fishes: Magical Objects in Natural History from Antiquity Through the Scientific Revolution," *Journal of the History of Ideas,* vol. 52, no. 3 (1991), pp. 373–98.

[5] Brian Copenhaver, "The Occultist Tradition and its Critics," in Daniel Garber and Michael Ayers, eds., *The Cambridge History of Seventeenth-Century Philosophy*, Volume I (Cambridge: Cambridge University Press, 1998), p. 459.

[6] Keith Hutchison, "What Happened to Occult Qualities in the Scientific Revolution?," *Isis*, vol. 73 (1982), p. 238.

objects like the remora from an exemplar of hidden properties into a mundane fish devoid of exceptional ontological or epistemological merit. Others tackled the fundamentals of Aristotelianism, removing the unintelligible occult quality and replacing it with other qualities that were both manifest and intelligible.

Ultimately, the Jesuit attack on the doctrine of occult qualities, as exemplified in these studies of the magnet and the remora, saw each of these objects stripped of their long-lived veneer of mystery to reveal, in the case of the magnet, natural and explicable causes for its occult powers, and in the case of the remora, no occult powers at all. Together, these two pre-eminent exemplars of the secrets of nature became commonplace, mundane, their ontological status shifted from the category of the preternatural into that of the natural.

That these Jesuits sought to abolish occult qualities from their Peripatetic philosophy was tied to the changing status of those qualities in the sixteenth and seventeenth centuries. Increasingly, they became an important front in the intellectual battles that defined this period. For example, the humanist scholar Julius Caesar Scaliger (1485–1558) exemplified the attitudes of those who saw these qualities as essential to natural philosophy. A staunch defender of Aristotle, Scaliger wrote in 1557 that

> to reduce everything to manifest qualities is the greatest impudence ... Many things have properties other than the qualities of the elements [i.e., the manifest qualities of hot/cold/wet/dry]; for temperate souls they remain completely hidden, but they deceive the meddlesome, those who think they can reduce all things to fixed, manifest qualities ... [T]hey mock that helpful refuge of occult properties ... [7]

His reference to the "helpful refuge" (*salutare asylum*) is interesting, for it suggests that he saw this doctrine as a haven of sorts, a philosophical space where the Peripatetic philosopher could contemplate even the most difficult and mysterious of natural problems. That Scaliger thought it worthwhile to defend occult qualities, however, also suggests that by the middle of the sixteenth century attacks on this doctrine were common enough that they necessitated a response.

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[7] Julius Caesar Scaliger, *Exotericarum Exercitationum lib. XV. de Subtilitate ad Hieronymum Cardanum* (Andreas Wéchel: Frankfurt am Main, 1576), p. 697: "Nam ad manifestas omnia deducere qualitates, summa impudentia est. ... Eorum nanque multa diversas habent ab elementorum qualitatibus proprietates: quae omnino latent animos temperatos, illudunt curiosis. Idemque isti, qui sese putant, cuncta ad certas causas reducere manifestas: tandem huc se devoluunt, ut decant, in oculis hominis, & Cateblepae esse principia contraria. Et tamen irrident illi salutare Asylum illud, occultae proprietatis."

We find a similar defense some decades later, in 1594, when Jesuit scholars at the influential Portuguese college at Coimbra published a commentary on the *Physics* of Aristotle.[8] By this time the college had come to exemplify the efforts made within the Society to codify and expand upon the Aristotelian philosophy that Ignatius Loyola had declared central to the Society's mission, and when its authors addressed the subject of the *echeneis* or remora, they moved swiftly from a description of its alleged properties to a discussion of occult qualities in general. Their reason for doing so soon became clear: they wanted to address the claim made by detractors of Aristotelianism that occult qualities were "the refuge of ignorance" (*inscitiae asylum*).[9]

The commentators at Coimbra argued against those who opposed the use of occult qualities by noting that "effects cannot always be assigned to the four primary qualities, as certain people falsely believe."[10] Occult qualities were thought to stand apart from the manifest, primary qualities of hot/cold/wet/dry, and this was necessary in trying to understand the remora; its ability to stop ships seemed to have no relation to the cold and wet nature of fish in general (since many fish possess the same manifest qualities but only one could stop ships) so, logically, some effects were only caused by other, hidden qualities. Though a simple argument, its implications were profound: far from encouraging ignorance or incomprehensibility, the Peripatetic doctrine of occult qualities articulated here actually worked to clarify the causes of particular effects by providing a philosophical tradition in which they could be considered without necessary reference to the primary, manifest qualities of substances.

Occult qualities and properties thus functioned as an adaptive concept that encouraged philosophical flexibility. Moreover, we know that students at Coimbra continued to receive an education that included occult qualities well into the seventeenth century because one such student, the physician Duarte Madeira Arrais, published his *Novae philosophiae et medicinae de qualitatibus occultis* in 1650. An exhaustive account of the occult properties and virtues found in nature, with particular reference to medical theory, Arrais used this

[8] For more on the Jesuits at Coimbra and their unique approach to Aristotelian philosophy, see Charles H. Lohr, "Jesuit Aristotelianism and Sixteenth-Century Metaphysics," in *Paradosis: Studies in Memory of Edwin A. Quain* (New York, 1976), pp. 203–20.

[9] *Commentarii Collegii Conimbricensis Societatis Jesu, in octo libros Physicorum Aristotelis*, lib. VII, cap. II, i (Lyon: Joannis Baptistae Buysson, 1594)—reprinted: New York: Georg Olms Verlag, 1984, p. 241: "occultas qualitates inscitiae asylum vocant."

[10] *Commentarii Collegii Conimbricensis Societatis Jesu*, p. 242: "Nec enim semper effecta ad quatuor primas qualitates, ut falsò quidam opinantur, referri queunt."

text to explain that such qualities were deemed occult because "though manifest to the intellect, they are not apparent to the senses."[11]

Though Scaliger, the commentators at Coimbra, and others believed that occult qualities were an essential component of natural philosophy, some of their Aristotelian contemporaries began in the seventeenth century to express serious reservations. Athanasius Kircher actually borrowed the terminology used at Coimbra when he asserted in his *Mundus subterraneus* of 1665 that occult qualities had become "the refuge of ignorance;"[12] earlier, he had assured his readers that "there is no occurrence in this work of hidden causes, because experiments made by me have not allowed it."[13] Likewise, the Jesuit professor of mathematics Francesco Lana de Terzi (1631–1687) used his *Prodromo* of 1670 to scoff at those who, when asked to explain the attractive power between the magnet and iron or between amber and straw, could suggest only that an occult quality was the cause:

> And if we demand further, of what does this occult quality consist, with which the magnet attracts to itself iron and not straw, and in the other case, with which amber attracts straw and not iron, they reply, this is the nature of the amber, and that of the magnet ... [14]

Such "explanations," Lana de Terzi argued, brought ruin upon natural philosophy.

Aristotelian reservations about occult qualities reflected an increasingly common attitude among early modern naturalists. Removing such qualities from natural philosophy was seen, especially by proponents of the "new philosophies,"

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[11] J.L. Heilbron, *Electricity in the 17th and 18th Centuries: A Study of Early Modern Physics* (Berkeley: University of California Press, 1979), p. 24.

[12] Athanasius Kircher, S.J., *Mundus subterraneus*, 3rd edn, vol. I (Amsterdam: Joannem Janssonium & Elizeum Weyerstraten, 1678), p. 314: "totius *ignorantiae asylum* destrueremus, ostenderemusque nullum tam occultae qualitatis effectum assignari posse, cuius causam genuinam experimentis non demonstraremus."

[13] Kircher, *Mundus subterraneus*, vol. I, *Praefatio Secunda ad lectorem*, p. iii.

[14] Francesco Lana de Terzi, *Prodromo; overo saggio di alcune inventioni nuove premesso all'arte maestro* (1670), p. 3: "Onde poscia interrogati, come si propaghi la virtu attrativa dell'ambra, o della calamita; come la luce si refranga in passare da un corpo più raro ad uno più denso; come si formino i sogni nella fantasia, onde procedano varii effetti simpatici e antipatici, e altre cose a queste somiglianti, altro non sanno rispondere, se non, che cio si fa per qualità occulte; che tale è la natura di quella sostanza; come se altretanto non sappia rispondere qual si voglia rozzo villano; e se noi si facciamo più avanti a dimandarli, in che consista quella qualità occulta, con cui la calamita tira a se il ferro, e non la paglia, e quell'altra, con cui all'incontro l'ambria tira la paglia, e non il ferro, essi ripigliano, questa essere la natura dell'ambra, e quella della calamita."

as forward-looking, and such thinkers were quick to denigrate those who clung to this doctrine.[15] Isaac Newton provided an example of such thinking in his *Opticks*, where he offered something of a retrospective on occult causes:

> The *Aristotelians* gave the name of occult qualities not to manifest qualities, but to such qualities only as they supposed to lie hid in bodies, and to be the unknown causes of manifest effects; such as would be the causes of gravity, and of magnetic and electric attractions, and of fermentations, if we should suppose that these forces or actions arose from qualities unknown to us and incapable of being discovered and made manifest. Such occult qualities put a stop to the improvement of natural philosophy and therefore of late years have been rejected.[16]

It is unsurprising that Newton should have connected occult qualities, and their injurious effect on natural philosophy, solely with "the Aristotelians"—this despite the fact that he himself placed occult causes squarely at the center of his own physics.[17] What Newton failed to note, however, was that some of those charged with upholding and defending Aristotelian explanations for insensible phenomena, such as the doctrine of occult qualities, found themselves motivated to devise new methodologies for exploring the unseen in nature. There were Jesuits among those who challenged this doctrine, and that they were permitted by the Society's censors to publish these attacks on occult qualities indicates that this changing attitude was not confined solely to these individuals, but rather existed in different places and times throughout the Society.

We saw in the previous chapter that some Jesuits were concerned about the ontological uncertainties provoked by the invisible parts of nature. They wanted to define, as sharply as possible, the boundaries that separated the natural from other categories of being, primarily the supernatural and preternatural. In turning their attention to two of the most prominent exemplars of the preternatural—the magnet and the remora—these and other Jesuits found a means of both ridding their shared philosophy of the troublesome doctrine of occult qualities and undermining the foundations of a category that too often blurred the all-important lines between nature and God. Thus, along with their attacks on the weapon salve, their critical approach to occult qualities exemplified their attempts to redefine the study of occult causes in the seventeenth century.

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[15] Heilbron, p. 19.

[16] Isaac Newton, *Opticks*, 3rd ed. (London, 1721), p. 377.

[17] John Henry, "Occult Qualities and the Experimental Philosophy: Active Principles in Pre-Newtonian Matter Theory," *History of Science*, vol. 24, no. 4 (1986), pp. 335–81.

Magnetism Made Manifest

In 1568 the mathematician and astrologer John Dee (1527–1609), known during his lifetime as an expert on the realms of the unseen, wrote in his *Propaedeumata Aphoristica*, "In the magnet, God has displayed to the eyes of mortals those things that should be observed, of the sort that, in other objects, he has left for discovery to the subtler investigations of the mind and to the greater diligence of experience."[18] Indeed, for many early modern thinkers the problems and perils of the invisible were nowhere more obvious than in the magnet or lodestone. Its properties and behaviors had puzzled the greatest minds of antiquity, and so it offered to their self-appointed successors, the "new philosophers" of the seventeenth century, an important means of demonstrating the power of modernity.

The relative frequency of magnets in early modern culture was one reason why the lodestone assumed a central place in discussions of the preternatural; unlike basilisks and remoras, the lodestone frequently appeared in even modest philosophical collections. Though it was far from ubiquitous, significant numbers of people nonetheless knew what it looked like, how it behaved, and quite possibly enjoyed an opportunity to use one. It is consequently of little surprise that, for thinkers in the seventeenth century, the magnet provided one of the most important opportunities to discuss and debate the insensible parts of nature.

The seventeenth century was, in fact, particularly important for the study of magnetism, thanks in part to the publication in 1600 of the *De magnete* (*On the Magnet*) of William Gilbert (1540–1603). His treatise on the magnet had a particular impact on Gilbert's leading critic and commentator in the Society of Jesus, Niccolò Cabeo, whose *Philosophia magnetica* (1629) was a subtle and complex effort to make magnetism manifest. In many respects, Cabeo's work on the magnet exemplified the responses to the crisis of certainty that were emerging in the early seventeenth century—more so, indeed, than did Gilbert's earlier work. Like Kircher and Lana Terzi, Cabeo attacked the Aristotelian doctrine of occult qualities as an explanation for the magnet's behavior, but he went further still, proposing instead a new kind of primary physical quality that he plucked from the shadows of philosophical obscurity and displayed alongside other primary Aristotelian qualities of motion and alteration.

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[18] John Dee, *Propaedeumata Aphoristica* (London, 1568), aph. xxiv: "Illa Deus in Magnete proposuit oculis mortalium spectanda, qualia aliis in rebus subtiliori mentis indagini, & sedulitati experiendi maiori, invenienda reliquit."

According to the *Natural History* of Pliny the Elder, a shepherd named Magnes discovered magnetism when he stumbled upon a rock that exerted a mysterious attraction upon the iron nails of his boots and the tip of his crook.[19] The simple experiments of Magnes the shepherd, though assuredly fictional, yielded no greater certainty as to the causes of magnetism than did the erudite speculations on the nature of the magnet from Plato, Aristotle, and Pliny himself.[20] The lodestone's ability to attract pieces of iron or other lodestones remained an enigma for close to two thousand years, though it was apparently similar to the attraction wrought by amber on pieces of straw, another phenomenon known to the ancients and discussed alongside magnetism for centuries.

One of the earliest speculations about the magnet appeared in the fragmentary writings of the ancient Greek philosopher Thales, who claimed that the magnet had a soul because it put iron into motion.[21] More than a thousand years would pass before a truly systematic study of the lodestone appeared: the *Letter on the Magnet* (1269) of Peter Peregrinus or Pierre de Maricourt (fl. 1261–1269). Peregrinus established that the magnet had two opposite poles and, after constructing a spherical lodestone that may have influenced William Gilbert's later experimental methodology, found that if one suspended a magnet on an axis, and then oriented it such that the axis pointed at the north celestial pole, then the magnet will rotate in harmony with the heavens. It did so, Peregrinus speculated, because the magnet received its power from the heavens, which themselves rotated once every twenty-four hours. The Franciscan Roger Bacon (ca. 1214–1294) rescued the work of Peregrinus from obscurity, and centuries later Jean Taisnier republished the *Letter* as his own work in 1572 and thereby inspired a new interest in magnetism.[22]

In the medieval Aristotelian tradition, which discussed the magnet with reference to occult qualities, philosophers posited a self-actualizing motion inherent in iron that caused it to move towards the magnet in much the same

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[19] Pliny the Elder, *Natural History*, 10, pp. 1–2.

[20] Both William Gilbert and Niccolò Cabeo justified their magnetic philosophies by pointing out the significant difficulties encountered by ancient authorities; Cabeo in particular discussed Pliny, Plato and Aristotle in his *Philosophia magnetica* (Cologne, 1629), p. 21.

[21] Though only fragments of Thales' own writings have survived, his ideas concerning the magnet were repeated by Aristotle in his *De Anima*, I, ii, 405a19: "And Thales, according to what is related of him, seems to have regarded the soul as something endowed with the power of motion, if indeed he said that the lodestone has a soul because it moves iron."

[22] On Peregrinus, see the modern rendering of his work, Pierre de Maricourt, *Epistle to Suggerus of Foncaucourt, Soldier, concerning the Magnet* (London, 1902); see also Stephen Pumfrey, *Latitude and the Magnetic Earth* (Cambridge: Icon Books, 2002), pp. 54–7.

fashion that a rock moved towards the center of the Earth. Thomas Aquinas advanced a similar theory but carefully distinguished magnetic attraction from gravity, claiming that while the latter acts over any distance towards a single point, magnetism acts on entire bodies and only across short distances. Nonetheless, the result was the same: the magnet, by acting on iron, induced a kind of natural motion.

Medieval explanations for the activity of the magnet persisted into the seventeenth century, but they shared the common problem that the actual quality inherent in the magnet that allowed it to attract iron remained fundamentally inexplicable because it was hidden; outwardly, the lodestone looked no different from many other stones. As a result, throughout its long history the magnet was often praised as the most clear and obvious example of occult attraction in nature. It became a paradigm case of occult qualities and actions to such an extent that it could in itself exemplify any number of occult causes and phenomena. For some early modern thinkers, including Niccolò Cabeo, the magnet became the ultimate test-case: these philosophers hoped to expand the method used to explain the magnet's activity to a wider range of occult phenomena as well.

The study of magnetism acquired new prominence with the *De magnete* of William Gilbert. A fellow of the Royal College of Physicians in London, Gilbert eventually became its president, and was also physician-in-ordinary to Elizabeth I. In his spare time he became interested first in chemistry and then in magnetism, and he spent eighteen years compiling what would become his greatest work.[23] Gilbert's importance to the study of magnetism lay not so much in the claims he made, however, but in the novel manner in which he made them. His method in the *De magnete* was fundamentally experimental, consisting largely of a series of claims based on detailed observations and demonstrations.[24] Gilbert himself saw this method as perhaps his greatest innovation, most especially when compared with the Peripatetic style of philosophical discussion still popular in the schools of the time. He made this clear in the opening words of his treatise: "In the discovering of secrets and the investigating of the hidden causes of things, clearer proofs may arise through more reliable experiments and

[23] For more on Gilbert, see Suzanne Kelly, "Gilbert, William," in the *Dictionary of Scientific Biography*, vol. 5 (New York: Charles Scribner's Sons, 1980), pp. 396–401; John Henry, "Animism and Empiricism: Copernican Physics and the Origins of William Gilbert's Experimental Method," *Journal of the History of Ideas*, vol. 62, no. 1. (Jan. 2001), pp. 99–119; Gad Freudenthal, "Theory of Matter and Cosmology in William Gilbert's *De magnete*," *Isis*, vol. 74, no. 1 (Mar. 1983), pp. 22–37.

[24] See, for example, Gilbert's entry in the *Dictionary of Scientific Biography*, vol. 5, p. 399, and Henry's "Animism and Empiricism."

demonstrated arguments, than through the probable guesses and pleas of the philosophizing rabble."[25]

His new method, Gilbert hoped, would open up the secrets of the magnet to a more general understanding. By the use of experiments "manifestly apparent to the senses," the reader would ascend from small claims to larger principles until "the causes of those things which, either through the ignorance of the ancients or the neglect of contemporaries have been unknown and overlooked, [are now] recognizable."[26] Gilbert's claims for a "new style of philosophizing" were also borne out through his ability to create a similarly new terminology, "words new and unheard-of," that would allow him to publish "plainly and fully" his speculations concerning "hidden things which have no name."[27]

Neither Gilbert's novel vocabulary nor his philosophical explanations for the magnet's behavior, however, were as clear and demonstrable as he might have wished his audiences to believe. For example, in differentiating the attraction between amber and straw from that between the magnet and iron, Gilbert described the former phenomenon as "electric" and claimed that "[such phenomena] induce motion by means of natural effluvia [which originate] from a humor," whereas magnetic attraction originated in "formal efficients, or rather, in primary powers," which he seemed to see as arising from the form of the lodestone itself.[28] Words "new and unheard-of," indeed—but what this "humor" might be, and how it differed from these "primary powers," was not entirely clear.

In the last section of the *De magnete*, Gilbert concluded that "the magnetic force is animate, or imitates the soul; to the human soul, while it is caught up in an organic body, it is superior in many ways."[29] Inadvertently or otherwise, he thus revived the opinion of the ancient philosopher Thales. His animistic explanation may have been rooted in an Aristotelian notion that self-motion was unique to substances with a soul, but also shared similarities with the *anima mundi* or world-soul first discussed by Plato in his *Timaeus* and embraced

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[25] William Gilbert, *De Magnete*, *Praefatio ad lectorem* (London, 1600), p. i: "Cum in arcanis inveniendis, & abditis rerum causis perquirendis, ab experimentis certioribus, & argumentis demonstratis, validiores existant rationes, quam a probabilibus conjecturis, & vulgo Philosophantium placitis "

[26] Gilbert, p. ii: "Ab illis magis praeclara emergunt, tandemque serie quaedam, globi telluris arcana maxime, & abdita reserantur, & eorum causae agnoscuntur, quae vel priscorum ignorantia, vel recentiorum negligentia, incognita & praetermissa fuerunt."

[27] Gilbert, pp. i–iii.

[28] Gilbert, p. 65: "Electrica naturalibus ab humore effluviis; Magnetica formalibus efficientiis, seu potiùs primariis vigoribus, incitationes faciunt."

[29] Gilbert, p. 208: "Vis magnetica animata est, aut animam imitatur; quae humanam animam, dum organico corpori alligatur, in multis superat."

by many Neoplatonists; for all of his railing against the philosophy of the schools, Gilbert's natural philosophy was actually marked strongly by traces of Peripateticism.[30]

Gilbert's lasting legacy, particularly in his native England, was his method of inquiry, the descriptive language in which he presented his experimental results and the claims he then drew from them. His first words in the *De magnete* demonstrate that he saw this method as the key to unlocking the causes of a phenomenon that had baffled philosophers from antiquity. At the same time, by explicitly opposing his method to the inquiries of "the philosophizing rabble" he undeniably threw down the gauntlet to those who would study the magnet in the decades that followed, the Jesuits in particular. His philosophical explanation for magnetic activity, however, did not fare as well. Discussions of magnetism in England, though they continued to refer to Gilbert, eventually turned to mechanical and corpuscularian explanations, leaving Gilbert's ideas behind.[31] Those who stepped up to advance his animistic theory, like the ardent advocate of the weapon salve Robert Fludd, adapted it to cosmologies that were heavily Neoplatonic, even hermetic in nature.[32]

The first and, arguably, most significant response to Gilbert's work to emerge from the Society of Jesus came in the form of Niccolò Cabeo's *Philosophia magnetica*. Indeed, the *Philosophia* is perhaps best understood as the Peripatetic answer to Gilbert, explaining the magnet without reference to either an occult or an animistic quality and, like Gilbert's *De magnete*, employing detailed demonstrations, experiments, and images as explanatory tools. Cabeo himself was explicit about his reasons for tackling the subject of magnetism:

> [I]f you seek to be able to know, from the school of the philosophers, why fire should induce heat, so that you do not seek refuge in an occult force or faculty, likewise, from this book you should be able to understand no less clearly why the

[30] On the scholastic treatment of self-motion, see Anneliese Maier, *On the Threshold of Exact Science* (Philadelphia: University of Pennsylvania Press, 1982), p. 43: "Only living beings are really capable of moving themselves, since they unite the mover (the soul) and the thing moved (the body) in the same subject." The implication here is that the soul makes self-motion possible, an idea with which Gilbert evidently agreed.

[31] For more on the reception of Gilbert in his native England and the fate of his magnetic philosophy there, see Stephen Pumfrey, "Mechanizing Magnetism in Restoration England: The Decline of Magnetic Philosophy," *Annals of Science*, vol. 44 (1987), pp. 1–22.

[32] Allen Debus, "Robert Fludd and the Use of Gilbert's *De Magnete* in the Weapon-salve Controversy," *Journal of the History of Medicine and Allied Sciences*, vol. 19 (1964), pp. 389–417.

> magnet attracts iron ... and why it turns itself to the pole, without another occult quality being thrust upon you.[33]

For contemporaries, this passage would have revealed a great deal: Cabeo was claiming that he could provide an Aristotelian explanation for the magnet's behavior without reference to the standard language of occult qualities. Moreover, we are meant to read his mention of fire and its ability to heat distant objects as a promise that, whatever methods Cabeo would use to explain magnetism without the use of occult qualities, he could expand and apply those methods to more phenomena than the lodestone.

Cabeo outlined an ambitious project in the *Philosophia magnetica*, especially significant because it signaled an approach to occult phenomena that potentially could transform contemporary Aristotelianism in new and startling ways. The work to which Cabeo was responding in his *Philosophia* had left its readers with an invisible and intangible cause for magnetism, but Cabeo set out to accomplish something that was both more novel and more radical, replacing an occult cause with one that was both manifest and thoroughly Peripatetic. His willingness to do so may have been tied to his identity as a member of the "neo-Aristotelians," proponents of a more liberal and, in some cases, more radical brand of Aristotelianism who began to appear in the decades around the beginning of the seventeenth century.[34] It is also noteworthy that even after he published his *Philosophia magnetica*, Cabeo remained willing to question the traditional foundations of the Peripatetic philosophy; in his commentary on the *Meteorology* of Aristotle, published in 1646, he embraced a probabilistic approach when he argued that knowledge of the weather and other meteorological phenomena could only be provisional, never certain, because the phenomena were themselves highly inconstant and accidental in nature. In making this argument, Cabeo joined the ranks of contemporary Aristotelians such as Pietro Pompanazzi and Agostino Nifo who also advocated for a probabilistic treatment of such phenomena, more proof that early modern Aristotelians were

[33] Cabeo, *Praefatio ad lectorem*, p. ii: "Si putas te ex philosophorum scholis scire posse, cur ignis calorem inducat, ita ut ad occultam vim, et facultatem non confugias, ex his itidem libris cognoscere valeas non minus clare, cur magnes attrahat ferrum ... et cur se ad polum convertat, ne tibi amplius occulta qualitas obtrudatur."

[34] On Cabeo's status as a neo-Aristotelian philosopher, see Stephen Pumfrey, "Neo-Aristotelianism and the Magnetic Philosophy," in John Henry and Sarah Hutton, eds., *New Perspectives on Renaissance Thought: Essays in the History of Science, Education, and Philosophy, in memory of Charles B. Schmitt* (London: Duckworth, 1990), pp. 177–89.

comfortable with debating and altering the epistemic standards by which they sought to understand the natural world.[35]

Deviating from the long-standing tradition of the scholastic commentary, the *Philosophia magnetica* belonged more properly to the genre of philosophical textbooks becoming more popular among neo-Aristotelian writers in the first half of the seventeenth century.[36] It also clearly articulated Cabeo's interest in the application of mixed mathematics to natural phenomena, allying him with the ideas of Christoph Clavius and, later, Athanasius Kircher.[37] The *Philosophia* was published in 1629, one year after a second, pirated edition of Gilbert's *De magnete* appeared in print, and from the first, Cabeo's links with Gilbert were obvious and unabashed. Even the frontispiece to the *Philosophia* was similar to the frontispiece published with the second edition of Gilbert's *De magnete* the year before, complete with an emblem depicting a ship that, though perhaps once lost amidst a turbulent sea, could now find its way safely to port with the use of the giant compass prominently displayed on its deck. The motto that accompanied this image—*Hic iam sua sidera norunt*—came from Virgil's *Aeneid*: "Here now they have come to know their own stars." The metaphor here was of losing one's way, of confusion and uncertainty that gave way to an understanding of the magnet's properties and the fashioning of one's "own stars" for use in navigation, an apt analogy to the confusion and uncertainty provoked by the study of occult phenomena in early modern philosophy.

Though Cabeo may have disagreed with Gilbert's conclusions, it is clear that he admired the Englishman's work. He explicitly structured much of his *Philosophia* around specific arguments and claims from Gilbert's *De magnete*, and he was more than willing to give Gilbert what he saw as his due, praising his experimental acumen while at the same disparaging the many errors in interpretation the Englishman made along the way.[38] For example, Cabeo refuted Gilbert's notion of an animating soul by stating that "a soul is not the motive power of the magnet, since no operations of life can be discerned

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[35] Craig Martin, "Conjecture, Probabilism, and Provisional Knowledge in Renaissance Meteorology," *Early Science and Medicine*, vol. 14 (2009), pp. 265–89.

[36] Pumfrey, "Neo-Aristotelianism and the Magnetic Philosophy," p. 181.

[37] On Cabeo's utilization of the "rhetorical resources" offered by mixed mathematics, see Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), pp. 63–7.

[38] Cabeo, *Praefatio ad lectorem*, p. ii. Cabeo described Gilbert's work thus: "Inde Gulielmi Gilberti Londinensis libros offendi de magno magnete Tellure, in quibus accuratissime magnetica experimenta inveni collecta."

in it."[39] Nonetheless, he recognized the truth behind Gilbert's criticism of Peripatetic explanations for magnetic activity, and Cabeo's project in the *Philosophia magnetica* was an attempt to overcome the deficiencies in such explanations for the magnet's activity while still adhering to the principles of the Peripatetic philosophy.

Gilbert's *De magnete* was a crucial influence on Cabeo's project, but it was not the only one; the latter also justified his project in the *Philosophia* by reference to others who had attempted to explain magnetism. In particular, Cabeo singled out two authors in addition to Gilbert: Giambattista della Porta (ca. 1535–1615), famed for his influential *Magia naturalis* that had first appeared in the middle of the sixteenth century, and a fellow Jesuit identified as Leonardo Garzonius of Venice. By mentioning these authors, Cabeo shaped an intellectual context for his work, allowing his audience to understand that debates about the magnet were both contemporary and wide-ranging. It is likely that most of his learned readers would have been familiar with at least the basic tenets espoused by Della Porta and Gilbert, both of whom enjoyed a wide audience in the early seventeenth century. Even if they had not read the work of Leonardo Garzonius, who wrote a treatise on magnetism in vernacular Italian rather than in Latin, his identification by Cabeo as a fellow Jesuit would have established his general philosophical orientation.[40] By referencing these authors, Cabeo laid out a rough map of competing interpretations, situating his own work within this ongoing debate between different philosophical camps.

Having provided a context for his study, Cabeo then produced an important, if ironic, justification for his treatise. Despite his eagerness to do away with insensible properties, he nonetheless depended upon the occult nature of the magnet to justify why he himself should have taken an interest in it:

> It is a fact we see in the magnet, whose nature is always obscured, that its properties seem to be mysterious: yea, the nature of this same stone has always been held to

[39] Cabeo, p. 36: "Non est igitur anima virtus motiva magnetis, cum in illo nullae vitae operationes deprehendantur ."

[40] The work in question was the *Due trattati ... della calamita*, or "Two Treatises on the Lodestone," which appeared in the late 16th century; a critical edition of the only known copy has recently been published: Leonardo Garzoni, *Trattati della Calamita*, ed. Monica Ugaglia (Milan: FrancoAngeli, 2005). Some brief biographical information on Garzoni is available in the *Bibliothèque de la Compagnie de Jésus*, Carlos Sommervogel, S.J., ed., Volume III (Eastford, CT: Martino Publishing, 1992), p. 1250.

> be such that, as I will say hereafter, it can be brought forth as an example of most obscure things not only by philosophers, but also by Theologians ... [41]

Because of the magnet's unique nature, both philosophers and theologians could use it as an "example of most obscure things," an argument that lent a forceful credibility to Cabeo's project. Theologians already possessed a deep concern with "most obscure things" and with the explication of the insensible, and here was an object that numerous thinkers employed as an example of the unseen. In fact, one could argue that Cabeo was justifying not only his own work here, but the wider philosophical program of the Society of Jesus as well. Jesuit contributions to philosophical culture were far from uncomplicated in the seventeenth century; some contemporaries viewed their self-proclaimed identity as both natural philosophers and theologians with skepticism, if not outright scorn, making any justification of their philosophical program all the more necessary.

Cabeo divided the *Philosophia* into four books. The first was devoted to "magnetic attraction," and included a review of the magnet's basic qualities, descriptions of its different kinds of motions, and various opinions on the causes for its behavior. This was also where Cabeo attempted to refute the numerous errors and misconceptions that had sprung up around the magnet in previous centuries. He argued, for example, that the *terminus* of the magnet's motion did not lie in the heavens—in other words, that the magnet did not move in response to the movement of a particular point in the heavens, as some earlier thinkers had suggested—nor in any one point in or on the Earth, such as the "imaginary [and] invented magnetic mountains" that many believed to exist at the northern terrestrial pole.[42] Cabeo refuted these ideas with a combination of experiment and basic geometry, borrowing at least some of both from Gilbert's work, and he replaced the notion of a single terrestrial point that was responsible for determining the orientation and movement of the magnet with the claim that, instead, the whole of the Earth was pervaded by a magnetic force, which he proposed to substantiate using a series of experiments.[43]

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[41] Cabeo, p. 1: "Id factum videmus in magnete, cuius semper natura abdita, proprietates arcanae visae sunt: imo talis semper habita est lapidis istius natura, ut, quod postea dicam, in exemplum obscurissimarum rerum non solum a philosophis, sed etiam a Theologis adducatur ... ."

[42] Cabeo, p. 52.

[43] Cabeo, pp. 57–66: *Universum terrae globum vim magneticam obtinere experimentis probatur*—"The entire sphere of the earth is shown by experiments to maintain a magnetic force."

Gilbert had argued that the Earth was itself a vast magnet, possessing the same qualities and behaviors as the smaller magnets with which he conducted his experiments, the ability to move being foremost among them. For Cabeo, as indeed for any orthodox Aristotelian, this was not an acceptable philosophical position. The immobility of the terrestrial Earth was a fundamental philosophical tenet for Aristotelians, but in the decades preceding the publication of Cabeo's *Philosophia* a number of rival philosophers had challenged the doctrine of terrestrial immobility, and numbers of Jesuits in turn had devoted considerable time and energy to refutations of both terrestrial motion and the Copernican hypothesis more broadly.[44] It should be noted, too, that the *Philosophia magnetica* appeared only three years before the sensational trial of Galileo, who had claimed that the Earth moved and in whose trial the Society of Jesus was heavily involved.[45]

While Cabeo's insistence on refuting the idea of terrestrial motion is not surprising, the manner in which he articulated that refutation deserves attention because it was here that he first laid out the identity of the quality responsible for the magnet's idiosyncratic behavior. Like a true logician, Cabeo moved his reader one step at a time towards his final conclusion, beginning with the different kinds of natural motion described by Aristotelian physics, and the proper place of the magnet within those categories. He pointed out that the four primary elements exhibited varying kinds and degrees of natural rectilinear motion: earth and fire possessed the most perfect rectilinear motion downwards and upwards respectively, while water and air exhibited the same rectilinear motion but did so imperfectly, resulting in the standard Aristotelian layering of the elements as earth lowermost, followed by water, air, and lastly fire as uppermost in the terrestrial realm. He then contrasted this natural rectilinear motion first with the perfect circular motion exhibited by the celestial bodies, which move around the central axis of the universe, and then with the *imperfect* circular motion exhibited by the magnet, which likewise moves (or, more properly, is moved) in an arc with respect to that central axis linking the two opposing poles of the universe.[46] Thus, Cabeo not only identified the magnet as operating differently from any other terrestrial substance, exhibiting circular rather than rectilinear motion, but also confirmed the magnet's activity as intelligible within an Aristotelian system of simple, natural, and manifest motions.

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[44] See, for example, Ann Blair and Irving A. Kelter, "The Refusal to Accommodate: Jesuit Exegetes and the Copernican System," *Sixteenth Century Journal*, vol. 26 (1995), pp. 273–83.

[45] For more on the Jesuit involvement in Galileo's trial, see Rivka Feldhay, *Galileo and the Church: Political Inquisition or Critical Dialogue?* (Cambridge: Cambridge University Press, 1995).

[46] Cabeo, pp. 38–43.

There was nothing especially novel about this argument. That one magnet, when influenced by another, could be made to rotate on its axis and thus move around its own center had been demonstrated by Peter Peregrinus in the thirteenth century; moreover, that the lodestone moved in an arc with respect to the magnetic axis of the Earth was demonstrable by even the most casual use of a magnetic compass. Gilbert had made much of these facts in his own magnetic experiments, relying as he did on a spherical lodestone that he called a *terrella* or "little earth" that he made to rotate under a number of conditions. Cabeo agreed with Peregrinus and Gilbert that magnetic motion was circular, but while Gilbert had consequently leaped to an erroneous and unsubstantiated conclusion created by a faulty syllogism—magnets can rotate, the Earth possesses magnetic qualities, therefore the Earth can rotate—Cabeo approached the question more carefully. Ultimately, he was able to take Gilbert's experimental results and transform them into a ringing endorsement of both Peripatetic cosmology and Aristotelian physics.

As proof that the terrestrial Earth sustains a magnetic force, Cabeo repeated an observation made by Gilbert: when the action of water exposed veins of metal in the ground, they were always found to run parallel to the Earth's axis—north–south, towards the poles—suggesting that a pervasive magnetic power or force determined their orientation within the Earth.[47] While he may have reiterated Gilbert's observation, however, Cabeo nonetheless transformed it at the same time into a demonstration of Aristotelian principles, able to do so by drawing an important distinction between claims that the Earth was a magnet in itself and the claim that the Earth merely sustained a magnetic force. In this way, the terrestrial Earth could share a particular quality with the lodestone without actually being one—it was not a magnet in itself; it was, instead, merely magnet-like in some respects.

It was the identity of this pervasive quality, however, that truly interested Cabeo. He described it, first, as primary, a key distinction. Most philosophers arranged the primary qualities in Aristotelian physics—those of alteration (hot and cold, wet and dry) and, in some cases, those of motion as well (gravity and levity)—in terms of opposition between one another. Between them, these six qualities provided the foundations for natural motion and change in Aristotelian physics. By establishing that this new quality was also primary, Cabeo was marking it out not as a hidden, idiosyncratic thing, but as a manifest and fundamental part of the natural world—in other words, not as an obscure quality that belonged only to one or two kinds of things, but one that inhered

[47] Cabeo, p. 58.

within any number of substances. Cabeo thereby expanded the qualitative foundations of Aristotelian physics while at the same time moving the magnet from the shadowy peripheries of natural philosophy to its very center.

Crucial to Cabeo's argument against Gilbert's mobile Earth, however, was the long-standing belief that primary qualities could only move substances towards their natural and proper ends, thereby making Aristotelian teleology possible in the natural world. The very function of primary qualities demanded that they act only to bring things to their respective *termini*, the goals and ends specified in their individual natures. In a geocentric cosmology, the natural and proper place of the Earth was at the center of the universe, and so its primary qualities must act to keep it there—the classical element of earth always moved towards that same center, and the terrestrial Earth, composed mainly of elemental earth, could only follow suit. Cabeo described it thus:

> [I]f the entire earth were moved violently from its proper place, it would naturally return to that place ... occupying not only its own center, the center of the universe, which is fashioned by gravity, but also directing itself lawfully towards the poles ... [48]

Here, then, we catch a glimpse of Cabeo's strategy. Gravity, as a primary quality, could only move the Earth towards its proper place at the center of the universe. Likewise, any other primary quality must act in the same way, and could not instead move the Earth in a superfluous or "improper" motion around its axis or around another body. By mentioning "the poles"—that is, the magnetic poles linked by a celestial axis cutting through the center of the universe and thereby the middle of the Earth—Cabeo set the stage both for his refutation of Gilbert's mobile Earth and for his discussion of a new, primary quality related to magnetism. The magnetic quality that had made terrestrial motion possible for Gilbert only confirmed for Cabeo that the Earth could *never* move, for the magnetic force pervading the Earth would produce only a stable, immobile alignment with the celestial poles.[49]

The new quality that Cabeo proposed to explain the wider question of the magnet's behavior was, in his words, "two-faced" or "two-sided" (*qualitas duarum facierum*).[50] Cabeo may have borrowed this terminology from Garzonius, his

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[48] Cabeo, p. 58.

[49] For more on the role of primary qualities and Cabeo's ingenious use of them, see Pumfrey, *Latitude and the Magnetic Earth*, pp. 226–7.

[50] Cabeo, p. 117: "Attractiones magneticas fieri per qualitatem duarum facierum."

contemporary in the Society, but it was Cabeo who explored it in full.[51] This two-sided quality encompassed both motion and alteration; in other words, it lay somewhere between the standard alterative qualities of hot/cold and wet/dry and the motive qualities of gravity/levity.

Cabeo's reasoning was actually very simple: the magnet was capable of both moving and altering, and the quality that caused this behavior must consequently embrace both of these facets. For example, he noted that "iron may be altered by a nearby magnet; that is, it acquires a certain new power and faculty that it did not have before, by which it is pushed towards the magnet, or is carried [there]."[52] The magnet changed or altered the iron before then moving it, and so the quality inherent in the lodestone that made this behavior possible must be both alterative and motive in nature. At the same time, the magnet not only induced motion but also experienced motion in itself, and Cabeo went to some lengths to establish how and why this quality should be understood as motive in character: "It is a motive quality just as gravity and levity can be called motive qualities; that is, it effects motion immediately and proximally, and causes motion upwards and downwards in this fashion, so that local motion can have a cause."[53]

Note Cabeo's use of the word "cause" (*causam*): the explanation he provided was truly a physical explanation in the Peripatetic sense, that is, an explanation of causes. In other words, he was able to translate magnetism from something caused by a shadowy, occult quality to a phenomenon that now belonged firmly in the realm of physics. Previously, occult qualities in general, and magnetism in particular, had been a metaphysical (rather than a physical) problem for mainstream Peripatetic thinkers, for two main reasons. Firstly, magnetism did not involve a "real" motive force. A magnet acting on a piece of iron did not itself produce a motive force as did an individual who lifted a rock from the ground; instead, the local motion experienced by the iron arose from within after it was affected by the magnet, a behavior that Aristotelians had difficulty explaining in detail. Secondly, magnetism did not appear to be rooted in the six active qualities of alteration and motion—hot/cold, wet/dry, gravity/levity—that philosophers

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[51] Pumfrey, "Neo-Aristotelianism and the Magnetic Philosophy," p. 182.

[52] Cabeo, p. 118: "Ergo ferrum praesente magnete alteratur, idest aliquam acquirit novam potentiam & facultatem, quam prius non habebat, qua ad magnetem urgetur, seu vehitur. "

[53] Cabeo, p. 121: "Est qualitas motiva, quia ficuti gravitas et levitas dicuntur qualitates motivae, quia illud, quod immediatè et proximè motum efficit, et causat, sursum, aut deorsum eo modo, quo motus localis potest causam habere." For more on Cabeo's discussion of the magnet's locomotion, see Pumfrey, "Neo-Aristotelianism and the Magnetic Philosophy," p. 183.

deemed "active" because they gave rise to agency and efficacy or, in other words, to natural motion and change, the purview of Aristotelian physics.[54] Thus, for many, a consideration of the magnet's behavior lay outside physics, in the realm of metaphysics.

In Cabeo's novel explanation for magnetism, however, the two main problems with the magnet evaporated. He addressed them both, first by proposing the *qualitas duarum facierum* that was in itself an active quality on par with heat and gravity, and then by identifying this quality as the cause for the motion experienced by both the magnet and the iron. This *qualitas* could act as an efficient cause because it was, now, an active principle. It was a brilliant solution to the Aristotelian problems with the magnet, transforming it in a single stroke from a metaphysical concern to a purely physical explanation. Compare this once again with William Gilbert's philosophy: Gilbert actually added a metaphysical dimension by positing an animistic or soul-like cause for the magnet's behavior. He and Cabeo were truly working at cross-purposes.

In the second book of the *Philosophia*, Cabeo made good on the promise he had made in the preface: namely, to extend his explanation for magnetism to the behavior of fire and its ability to heat distant objects. He did so by quoting at length a portion of another text by Jean Fernel (1497–1558), a well-known French physician; though Cabeo did not provide the title of this treatise, it was in fact Fernel's *De abditis rerum causis* (*On the Hidden Causes of Things*), which first appeared in 1548.[55] In the relevant passage from Fernel's text, the interlocutor called "the Philosopher" tricked the other, Brutus, into marveling at the behavior and nature of a mysterious substance later revealed to be fire. Brutus protested that this trick was "worthless, and entirely trite [*maximè protrita*],"[56] but in Fernel's text the Philosopher went on to reply that many were content to refer to the activity of fire as heat and light, but that of the magnet as merely occult, because the former was more familiar than the latter. Brutus then conceded that "the properties of things stem ... solely from the form, and that they are not correctly called occult properties, but properties either of the form or of the total substance."[57] In other words, qualities deemed "occult" were only called such because of ignorance or unfamiliarity; we should speak of the

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[54] For more on this, see Maier, pp. 43–7.

[55] Jean Fernel, *De abditis rerum causis libri duo* (Venice: D. Petri & Joan. Marie de Nicolinis de Sabio, 1548).

[56] Cabeo, p. 120.

[57] John M. Forrester, ed., *Jean Fernel's* On the Hidden Causes of Things (Leiden: Brill, 2005), p. 685.

magnet as we do of fire, confident that the causes of its behavior are real and, with more knowledge, will become manifest.

Thus, Cabeo found at least some support for his ideas in the work of Fernel—Cabeo's eagerness to do away with occult qualities meshed with his claims that, in his explanation for magnetism, one could find, too, an explanation for the activity of fire. Indeed, he suggested that his "two-sided" quality provided a causal explanation for the behavior of fire as well, which not only experiences a form of locomotion (upwards, in this case, and only in one direction, unlike the magnet, which moved in an arc towards either of the magnetic poles) but also induces an alteration in substances that we call heat. In Cabeo's own words, "It is entirely sufficient if you declare the cause [of the behavior of fire] to be a two-sided quality, which produces these motions, and not an occult cause, which should be more scorned."[58]

There is ample evidence for Cabeo's rejection of occult or insensible qualities as philosophical causes. He used simple, manifest natural motions and the primary qualities of alteration and motion that had supported Aristotelian physics for centuries to explain his "two-sided" quality as an altogether novel cause for magnetism and, by extension, for other phenomena as well. It is noteworthy, however, that the reasoning that led him to propose this quality and even some of the experiments he used as demonstrative proofs of its existence were rooted firmly in the medieval scholastic tradition. Thomas Aquinas, Jean Buridan, and other scholastic thinkers in the thirteenth century had observed that the lodestone altered iron; that this alteration then induced iron to move itself towards the magnet was another medieval commonplace, if one that lacked a coherent explanation. In fact, the experiment described by Cabeo to prove that the lodestone could alter iron merely demonstrated something known in antiquity: exposure to a lodestone magnetizes a piece of iron so that it can then attract other pieces of iron to itself. Moreover, the experiment that Cabeo used to demonstrate the motive powers of the magnet was precisely the experiment recorded by Peter Peregrinus in the thirteenth century, in which two lodestones floating in water caused one another to rotate as a consequence of their mutual attraction and repulsion.[59]

That Cabeo could use such simple and long-standing demonstrations to prove his point places his explanation for magnetism squarely in a philosophical tradition stretching back to medieval scholasticism and beyond. At the same

[58] Cabeo, p. 120: "Optimè satisfit, si dicas causam esse qualitatum duarum facierum, quae hos motus efficit, nec in occultam amplius causam reijciendum."

[59] Cabeo, pp. 123–4.

time, however, his ability to reinvent such commonplaces to suit his own purposes testifies to his ingenuity. It was not only Gilbert's ideas that Cabeo transformed into an endorsement of his magnetic philosophy, but the medieval roots of early modern Peripateticism as well.

Having provided the *qualitas duarum facierum* to explain not only the magnet but also a range of other phenomena previously thought to operate by means of occult qualities, Cabeo proceeded in the third book of the *Philosophia* to lay out a series of observations describing everything from the behavior of iron once it was exposed to a magnet to how one could use a magnet to find the latitude of a particular region or "the altitude of the pole." For the most part, these were not novel observations; instead, they were reiterations of demonstrations and observations recorded by Gilbert and others who had experimented with magnets. Likewise, the fourth and final book of the *Philosophia*, concerned with both the causes and effects of magnetic attraction, was something of a catch-all for a variety of problems, many rather prosaic. It was here that Cabeo wondered "why the causes of such [i.e., magnetic] attractions can have been, until now, truly unknown."[60] He then proposed to address "all manifest effects that arise out of this attraction, and which seem to me to have an insufficiently easy cause," using the same methods he had employed previously in the *Philosophia*, before bemoaning the mistakes made by others whose "feebleness" had led them to exaggerate their ignorance of occult causes. This, Cabeo admitted, was why "for so long I believed the occult magnetic Philosophy to have lain in ruins."[61] He hastened to assure his readers, however, that he would not give up; in a somewhat odd turn of phrase he compared himself to a mechanical contrivance that would work as long as necessary to hoist an explanation for magnetism free from obscurity: "I do not refuse to spin around and around if perhaps, because I pull for so long a time, I will finally rescue [an explanation for magnetism] from the shadows."[62]

What followed was a series of basic experiments demonstrating various properties of the magnet. For example, Cabeo established that the opposing poles of a lodestone draw one another together, but that two similar poles on two lodestones always flee one another. He also provided evidence that if one divides a magnet in two and suspends one part over another, its parts do not attract one another with any greater force than if two entirely different lodestones were brought together. Later, he described what happened when two magnetized

[60] Cabeo, p. 285: "Cur istius attractionis causae adeo hactenus ignotae fuerint."

[61] Cabeo, p. 285. "Hac de causa tamdiu putarim ego magneticam Philosophiam occultam iacuisse."

[62] Cabeo, p. 286: "Iterum iterumque versare non recuso, si fortasse, quod tamdiu traho, tandem è tenebris extraham."

needles were placed near to one another and allowed to move freely—they will come to a parallel arrangement due to the simultaneous attraction and repulsion of their various parts—and clarified that, "properly, the magnet neither draws iron, nor does iron call the magnet to itself, but both parts of the pair come together by reciprocal exertion."[63]

These were hardly earth-shattering observations, but they were notable in that Cabeo provided detailed explanations for the causes of each while, at the same time, providing simple diagrams to aid the reader in understanding. For example, on the question of why contrary poles attract and similar poles repulse one another, he had this to say:

> Thus, in a nutshell, the reason why similar faces in magnetic bodies may flee each other, [while] opposite [faces] may be conjoined, is that magnetic things want [*volunt*] to arrange themselves reciprocally so that the qualities they possess in themselves might lie in conformity to the quality that has been sent forth into the medium, so that in this way they—who might be offended by one another—might thus [instead] gratify each other by turns."[64]

This language of "wanting," of magnets offending and gratifying one another, is certainly evocative, but at the same time it remains true to the Aristotelian tone of the *Philosophia*, as we shall see shortly.

Cabeo also weighed in on several stories and myths concerning the magnet, including the false magnetic sympathy that he used to refute the purported activity of the weapon salve, as well as the long-lived myth that Muhammad had been interred in an iron casket made to hover in mid-air by giant magnets hidden in both floor and ceiling. Cabeo concluded that such a feat would certainly be possible, basing this on his own experiments: "[I]ron can be arranged by a physical action between two magnets, balanced so that it approaches neither, but hangs freely in the air."[65] He later noted that "perpetual motion does not seem to be able to come about through magnetic attraction," but also proposed

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[63] Cabeo, pp. 287, 288, 294, 346.

[64] Cabeo, p. 288: "Ratio igitur breviter, cur similes facies in magneticis corporibus se fugiant, oppositae coniungantur, est, quia magnetica volunt se invicem disponere, ita ut qualitas, quam habent in se, conformiter iaceat ad qualitatem in medium effusam, ut sic potìus iuvent se invicem, quam ab invicem laedantur."

[65] Cabeo, pp. 334–5: "sed etiam physica actione potest constitui ferrum inter duos magnetes ita libratum, ut ad neutrum accedat, sed in libero aere dependeat Testor me id fecisse."

to discuss, if it was actually possible, "by what means it should be tested."[66] He also refuted the myth, handed down from antiquity, that contact with a diamond could render a magnet powerless.[67]

Stepping back, then, we have a clear view of the *Philosophia magnetica* as Cabeo constructed it. He began by refuting the errors and acknowledging the successes of other thinkers, Gilbert prominent among them, before proposing his *qualitas duarum facierum* as a philosophical cause for the observed behavior and properties of the magnet. He then made good on his earlier promise to extend this reasoning to other phenomena, such as fire, before describing and explaining a wide range of demonstrations and problems involving magnetism while, at the same time, either countering or confirming a variety of myths and legends.

If, however, Cabeo solved the problem of causation by replacing an occult and idiosyncratic cause for magnetism with one that was both primary and active, in the Aristotelian sense, he still had to explain the magnet's ability to act on iron without touching it. This was the problem of action-at-a-distance, which bedeviled numerous attempts to explain occult phenomena in this period, but again it was a comparison with fire that would assume particular importance.

Peripatetic natural philosophy often drew comparisons between phenomena like the magnet and fire because they could affect substances without physically touching them. They exemplified a kind of insensible agency or, to put it another way, an insensible means whereby two objects could interact without physical contact. This was not the prohibited action-at-a-distance, however, for in Aristotelian physics two substances could interact with one another only by some form of contact. Like much in Aristotle's philosophy, this was a common-sense sort of idea, and the medieval commentators on Aristotle, too, thought of this as a reasonable notion, but one that raised serious questions in the face of phenomena that appeared to act *without* sensible, physical contact. A common example cited by the medieval commentators, and one that Cabeo himself exploited, was the heat produced by fire: a fire could warm an object from several feet away, which meant that the fire somehow acted on that object without directly touching it. Medieval philosophers usually explained this by claiming that fire possessed the active quality of "hotness," which not only defined what fire was (acting as a formal cause) but could also induce "hotness" in other objects as well (acting as an efficient cause—recall that heat or "hotness"

[66] Cabeo, p. 338: "Motus perpetuus non videtur posse fieri per magneticam attractionem; & si posset fieri, quae esset tentanda via."

[67] Cabeo, pp. 350–52.

was one of those active principles that could cause such an alteration). But while this active quality was the cause of heating-by-fire, the means whereby this quality might act on a distant object was another question altogether.

Another important example of action-at-a-distance was the propagation of light, which Jean Buridan (ca. 1295–1358) discussed as a phenomenon dependent upon the "multiplication of species." According to this theory, some bodies diffused their respective qualities or species through their surrounding medium and upon other bodies, and the pre-eminent example of this phenomenon was the propagation of light. An incandescent source impressed its species—a similitude of itself—upon a transparent medium like the air, but it was only at the surfaces of translucent or opaque bodies that this species became apparent to the gaze of an observer. This is important because the species of the source (or of the agent, to use proper Aristotelian terminology) only became actualized when it encountered something receptive to it (again, in Aristotelian terminology, this was the patient, the passive component in this exchange). In the case of light, an individual species of *lux* had no effect on a transparent object such as the air, which was not properly receptive to it, but changed the surface of a receptive body or patient such as a piece of rock, lending it color and making it visible. Likewise, when Buridan and others turned to the magnet, they theorized that it multiplied its own species through an intervening medium until they encountered a piece of iron, which possessed, for lack of a better way to put it, the quality of "being able to be moved by the magnet." The air, conversely, or a piece of wood, did not possess such a quality, which explained why they were unaffected by magnetism.[68]

Cumbersome though it might have been, the multiplication of species did provide medieval thinkers with a means of discussing phenomena like the magnet without violating the fundamental precepts of their natural philosophy. This was, as the scholastics put it, a kind of "virtual contact," as opposed to direct or corporeal contact: even if the magnet never touched the iron physically, it still did touch it with its propagated qualities or species. The same was true for fire: it made distant objects hot by propagating the active quality of "hotness" to them.

Cabeo embraced a similar explanation for magnetism—he claimed repeatedly that magnets possessed qualities that they "sent forth into a medium." He also followed his medieval forebears in using the propagation of light as a

[68] Heilbron, pp. 22 and 23. For a cogent explanation of these medieval theories, see the work of Roger Bacon as edited and translated by David C. Lindberg: *Roger Bacon's Philosophy of Nature: A critical edition, with English translation, introduction, and notes, of* De multiplicatione speciorum *and* De speculis comburentibus (Oxford: Clarendon Press, 1983).

close analogy to the behavior of the magnet, pointing to the diffusion of light, for example, to explain and demonstrate the principle of a "sphere of activity" which, as we saw in the previous chapter, was a crucial element in Jesuit refutations of the weapon salve. The magnetic force, Cabeo argued, emanated from the magnet in the same manner that light emanated from an incandescent source, namely, with equal intensity in all directions.[69] Moreover, that intensity waned as the distance from the source increased, producing a limited sphere within which the quality diffused with full potency.[70] As well, like light, the magnetic force was an immaterial change in quality diffused through a medium to a receptive body, rather than a material or mechanical alteration. As a result, Cabeo claimed that he could find no better example to explain the diffusion of the magnetic force than the activity of light.[71]

The connection that Cabeo forged between magnetism and illumination was no accident. Throughout the *Philosophia magnetica* one finds repeated references to seeing, exposure, illumination, and visualization, often mediated by the simple woodcuts scattered throughout the text. Cabeo emphasized over and over again that the exercise of one's eyes was crucial to a proper understanding of magnetism; indeed, even in the first pages of the *Philosophia* where he promised to do away with the medieval, scholastic language of occult qualities, Cabeo also hinted at the importance of imagery and vision as part of his wider project. He used a rhetoric of light and shadow to characterize the revelation of the magnet's hidden force as a metaphorical illumination of obscuring shadows, but importantly he framed this as part of his justification for his extensive use of imagery:

> ... I add diverse shapes and depicted forms [i.e., drawings] of things, where I have judged that the matter requires it, so that the thing itself is placed before not only minds but also eyes, if this is possible, so that the secrets of the magnetic nature, which to so many have always seemed wrapped up in darkness, now allow the eyes of all, and if [these images] were to seize upon [the secrets of the magnetic nature], [these secrets] would easily deliver themselves in the viewing.[72]

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[69] Cabeo, p. 124: "Dixi praeterea hanc qualitatem diffundi ea ratione, qua lumen à luminoso disseminatur."

[70] Cabeo, p. 125.

[71] Cabeo, p. 124.

[72] Cabeo, *Praefatio*, p. iii: "variasque adjicio figuras pictasque rerum formas, ubi rem id exigere iudicavi, quo res ipsa non solum animis, sed etiam oculis, si fieri possit, subjiciatur; ut arcana magneticae naturae, quae tantis semper involuta tenebris visa sunt, iam oculos omnium admittant, et facilia, si contingant, dent se in conspectum."

Note the emphasis Cabeo placed on revealing the hidden secrets of the magnet, its occult properties and qualities, to the eyes of the reader through the use of "shapes and depicted forms." His rhetoric here, in which the images themselves "seize upon" the secrets of magnetism and then deliver them up to the eyes of the viewer, was more than merely suggestive: he stated clearly that only a juxtaposition of philosophy and image, or, as he phrased it, the work of both mind and eye, could reveal the secrets of the magnet.

This was not the only place in the *Philosophia* where Cabeo emphasized the importance of seeing. Just before the first woodcuts of the treatise appeared, he stated again that the topic under discussion, in this case the magnet's motion towards the poles, should be subjected first to the eyes so that it might properly be sought out and understood.[73] That the reader then turned the page and found a pair of woodcuts only reinforced the connection between Cabeo's insistent rhetoric of placing such matters "before the eyes" and the presence throughout the *Philosophia* of such images. This emphasis on figures and pictures allowed the *Philosophia magnetica* to function as an exercise in seeing, a fact that Cabeo seemed to believe was crucial for a full and proper understanding of the magnet. The reader came to that understanding not only through the application of his mind, but through the application of his senses as well, and in this respect at least, Cabeo and William Gilbert were aligned closely.

Some of the images in the *Philosophia magnetica* went further still, not merely conveying Cabeo's interest in placing information before the eyes of his readers, but also working out on the page itself the project at the heart of the work, namely, making magnetism manifest. Consider, for example, two images that Cabeo used to make visible the force or power that emanated from the poles of a typical lodestone. In the first, he presented an abstract portrayal of that force, demonstrating that it moved in straight lines and in all directions from each pole. The second image is more interesting, however, for it depicts a real-world example of magnetism in action: here, Cabeo shows us the result of a experiment in which iron filings are made to follow the lines of force emanating from each pole of the lodestone. It is the kind of simple experiment that children still carry out today, but in the context of the *Philosophia magnetica* it becomes a wonderfully evocative illustration—both literally and figuratively—of Cabeo's wider project. Here, we see the invisible force of the magnet for ourselves, made manifest first by Cabeo's experiment and then by the image that transforms Cabeo's experience into our own.

[73] Cabeo, p. 5: "Nos rem ipsam oculis prius subjiciamus, ut cognito an sit, ex philosophi praecepto, ad indagandum propter quid, gradum commodè faciamus."

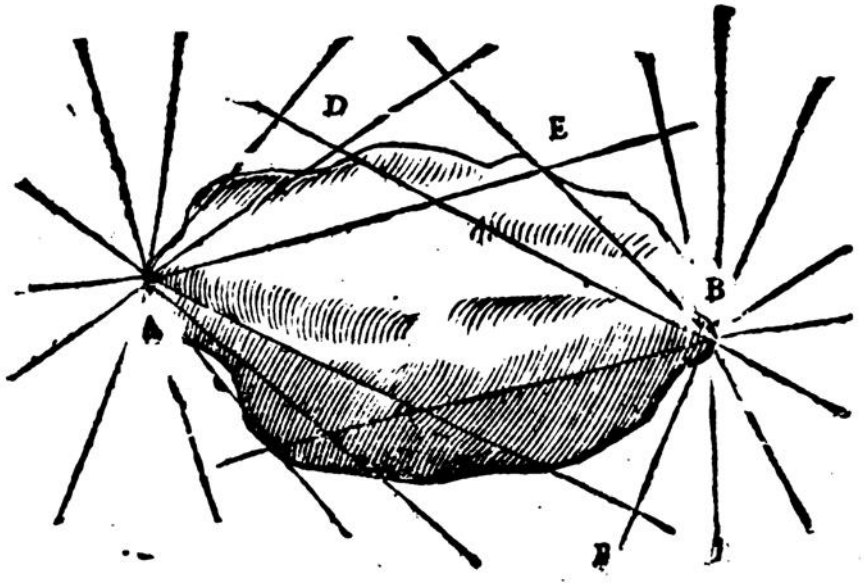

Figure 3.1a An illustration found in the *Philosophia magnetica*, depicting an abstract representation of the magnetic force.

Source: Courtesy Bavarian States Library Munich, shelf number 2 Phys.sp. 3, p. 243.

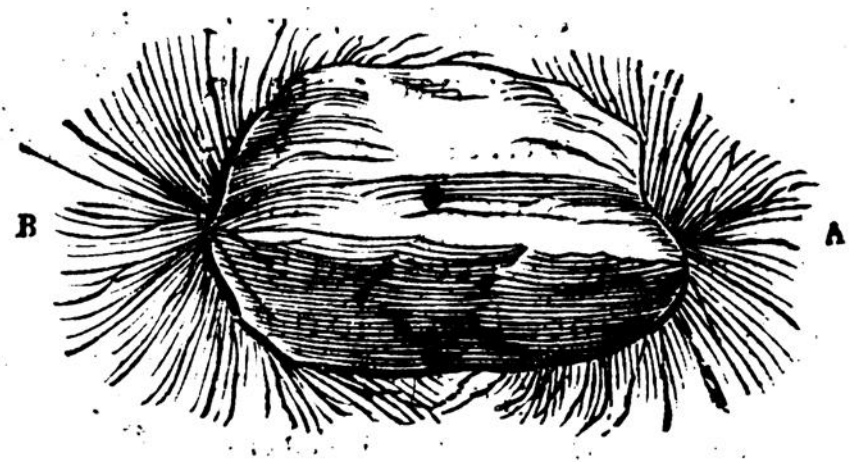

Figure 3.1b Another illustration from the *Philosophia magnetica*. Here, Cabeo has reproduced the appearance of iron filings affected by the lodestone's invisible power.

Source: Courtesy Bavarian States Library Munich, shelf number 2 Phys.sp. 3, p. 18.

A Fish Like Any Other

The *echeneis* or remora often appeared alongside the magnet in early modern discussions of occult causation. From antiquity onwards it was known to be a small fish capable of stopping ships dead in the water merely by attaching itself to their hulls. While the magnet was subjected to new and rigorous kinds of philosophical inquiry in this period, however, the remora suffered a rather more ignominious fate. Increasingly stripped of mystery and exoticism in contemporary natural histories, the remora became simply another fish, devoid of any occult agency whatsoever. Gaspar Schott was not the first Jesuit to do this to the remora, but his discussion of its alleged properties represents the end of an era; he not only summarized its long and contentious natural history but also pronounced a definitive end to its status as an occult object. His description of the remora thus stands in stark contrast to the erstwhile defense of occult properties written by the Jesuits at Coimbra in 1594, a defense inspired originally by this same fish.

Schott has received relatively little attention from historians, though there is ample evidence that he was an inventive (if not always original) thinker. After entering the Society of Jesus in 1627 at the age of nineteen, he made his way to the university at Würzburg and studied there with Athanasius Kircher until the Swedish invasion of the Palatinate in 1631, at which point he and Kircher fled southward. After finishing his education at Palermo, Schott remained there for another twenty years as a teacher before journeying to Rome and collaborating with his former master at his museum in the Collegio Romano. Eventually returning to Germany, Schott quickly established an extensive network of correspondents following the publication of his *Mechanica hydraulico-pneumatica* (1657), originally intended as a catalogue of the hydraulic and pneumatic instruments in Kircher's collection but that also included details of the pneumatic experiments conducted by Otto von Guericke, Robert Boyle, and others. His correspondence with thinkers across Europe worked its way into Schott's published works, alongside descriptions of experiments and detailed schematics sent to him while he lived and worked in Germany.

The *Physica curiosa* of 1662[74] was Schott's attempt to describe the wonders of the natural world; his discussion of artificial wonders would appear two years later in his *Technica curiosa*. Taking the form of an encyclopedia of natural objects and phenomena that ranged from the mundane to the preternatural, the *Physica curiosa* also demonstrated Schott's continuing interest in the unseen

[74] Gaspar Schott, S.J., *Physica curiosa, sive, Mirabilia naturae et artis* (Nuremberg: Johannis Andreae Endteri & Wolfgangi Junioris Haerdum, 1662).

world. Divided into twelve books, the first addressed angels and demons, and the second, ghosts and other apparitions. Interest in such subjects was not unusual, even in the latter half of the seventeenth century—consider, for example, Joseph Glanvill's exhaustive discussion of witchcraft and spirits in his *Saducismus triumphatus* of 1681.[75] There was nothing particularly original about Schott's treatment of these issues; he did little more than rehearse what would have been, for his readers, fairly standard interpretations of demonic activity and ghostly hauntings. Their inclusion here is noteworthy, however, because apparitions and the wonders worked by demons traditionally fell into the realm of the preternatural. We should see the *Physica curiosa*, then, as concerned mainly with the fluid boundary between ontological categories. The marvels described by Schott in these first sections carried echoes of the supernatural—he also discussed divine portents and "those possessed by devils"—but gradually the tone of the book changed, moving from "the varied forms of men" (including centaurs, hermaphrodites, and giants, examples of the rare and exotic that would also have been consigned to the preternatural) to rather mundane lists of animals, divided into the terrestrial, aquatic, and aerial realms.

The shift from marvels wrought by devils, spirits, and nature itself to encyclopedic natural histories of beasts and birds evinces a wider shift in ontology, from genuinely preternatural phenomena to naturalistic accounts of supposedly "marvelous" animals, and the transition from genuine marvel to the simply mundane is most clearly embodied in the *dissertatio physiologica* devoted to the remora which, at twenty-nine pages, was a clear outlier in a book where every other animal received no more than a page or two. Schott took some pains to note that the remora had existed as an exemplar of occult properties from antiquity onwards. The problem, however, was that thinkers stretching all the way back to Aristotle had consistently misidentified the fish itself. Aristotle had been the first to discuss the *echeneis*; Pliny, following Aristotle, had claimed (erroneously) that the latter had described the remora as possessing *pinnae*, feathers or wings. Pliny then created great confusion for future generations of naturalists when he linked together the *pinnae* of the *echeneis* or remora with the *spinae*, or spines, of the *echinus* or sea urchin.[76] Pliny also had suggested that a fish with a shell, a *concha*, was responsible for halting ships in the water as the remora was thought to do.

[75] Thanks to his interest in witchcraft and related phenomena, Glanvill also found himself embroiled in ontological debates concerning occult causation; for example, see Thomas H. Jobe, "The Devil in Restoration Science: The Glanvill-Webster Witchcraft Debate," *Isis* 72 (1981), pp. 342–56.

[76] Copenhaver, "A Tale of Two Fishes," p. 376.

Schott summarized this confusion in detail, concluding finally that

> there are three fish that have been described principally by the ancients with the name of "remora": one that Aristotle and Pliny assert to be small, and to adhere to stones; another that comes from the class *concharum*, which is called a conch by the ancients ... ; and third, an eel a cubit long, large with respect to the preceding fish. Many of the more recent authors have confused these three into a single fish.[77]

Schott went on to detail these more recent errors, describing those contained in works by naturalists as diverse and venerable as Albertus Magnus, Girolamo Cardano, Julius Caesar Scaliger, Konrad Gesner, and Ulisse Aldrovandi. Following this recitation of errors came "examples of ships said to have been detained by the *echeneis*," as well as a consideration as to "whether the *echeneis* not only slows ships, but stops them as well" and to what part of the ship it should attach itself to have the greatest effect.

In the following pages, Schott discussed the varied explanations for the remora's wondrous ability to slow or stop ships, rejecting each in turn until he reached that of Athanasius Kircher, who ascribed the mysterious slowing of ships at sea not to the remora at all, but to "contrary tides or currents, which happened to be in those places where ships were delayed."[78] Schott added that this doctrine was "evident and right," before going on to enumerate Kircher's objections to the supposed powers of the remora. Interestingly, these objections were closely related to Kircher's objections to the weapon salve discussed in the previous chapter. As with the salve, he compared the reputed activity of the remora to that of the magnet—the latter was natural and possessed of properties well established by scholars, whereas the former suffered by comparison. For example, Kircher characterized as "absurd" the idea that one small remora could halt a massive ship; its supposed power was entirely out of proportion with its size, and everyone knew that size mattered when it came to magnetic attraction: larger magnets possessed greater attractive power.

Eventually, Schott himself weighed in on the subject. He began by admitting that "it is not certain" how so lowly an animal might impart so great a power to ships that it slows or stops them, before adding, "Indeed, it seems probable to

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[77] Schott, *Physica curiosa*, vol. II, p. 1312: "Ex quibus constat ... tres potissimùm pisces Remorae nomine celebrari apud veteres: unum quem Aristoteles & Plinius parvum esse ajunt, & saxis haerere: alterum ex genere concharum, quem concham veneream vocari ... ; tertium cubitalem, & respectu prioris magnum, anguilliformem. Hos tres multi Auctores recentiores confundunt in unum piscem."

[78] Schott, *Physica curiosa*, vol. II, p. 1329.

me that this is altogether fabulous and false."[79] He stated later, "It is probable that those effects of detaining ships, which have been ascribed to the *echeneis*, are actually mere happenstance; they do not originate always and everywhere from a single cause [i.e., the remora], but from many." The reputed power of the remora was so widely-known, Schott suggested, that in cases where ships mysteriously slowed or stopped altogether, people would seize upon the tiny fish as the likely cause, whatever the evidence. Ultimately he concluded that "the cause of the detention and slowing of ships, which is ascribed to the remora, was probably the surges of the sea."[80]

Thus, in the course of this long *dissertatio*, Schott plucked the fabled remora from the category of the preternatural where it had rested for centuries and tossed it into the realm of the natural. It was not an exemplar of occult and wondrous properties after all; the effects ascribed to it were the result of coincidence or natural perturbations in the sea. Everyone from Aristotle onwards had been wrong, and ultimately it was only Schott himself (and, of course, his mentor Kircher) who saw the remora's reputed power for what it was: namely, nothing. The way in which Schott singled out the remora, giving it many times more space than any other individual creature, as well as its place in a work that had already sought to shift ontological scrutiny from marvels to the mundane, suggests that he had a clear goal in mind. Ultimately, as we shall see in later chapters, stripping the remora of its occult status fit perfectly into Schott's wider project in which the mysteries of nature were exposed to view and revealed as prosaic and easy to understand.

We return, then, to Pierre Gassendi's assertion that the whole of nature was nothing more than magnets and remoras. For him, and indeed for many others in the seventeenth century, this was true; they were content to proclaim that the varied operations of nature were, as Walter Charleton said, "meer Secrets." But while these self-styled reformers of natural philosophy scoffed at the Peripatetic doctrine of occult qualities, at least some within the Society of Jesus were working to banish those qualities altogether. Gassendi's complacent belief that our knowledge stopped at "the bark of things" was not enough for either Cabeo or Schott, both of whom sought to root out Charleton's "meer Secrets" and strip away from these objects any intimation of an occult or mysterious power. It was the keystone of a sweeping exercise in revelation, and one that, as we shall see, was not confined solely to these texts and their authors.

[79] Schott, *Physica curiosa*, vol. II, p. 1335: "Imò probabilius mihi videtur, illud omnino fabulosum ac falsam esse."

[80] Schott, *Physica curiosa*, vol. II, p. 1337: "Causa retentionis ac detentionis navium quae echeneidi adscribitur, fuit probabiliter aestus maris. "

Efforts to alter traditional explanations for occult activity were not without controversy, however. The *Ordinatio pro studiis superioribus* of 1651, intended to elucidate for Jesuit educators those doctrines that should be taught and those that should not, made no overt mention of occult qualities but did condemn the notion that there were "more than four primary sensible qualities."[81] While Cabeo's work was not mentioned specifically, it seems likely that this prohibition was related, at least in part, to his radical reinterpretation of Aristotelian qualities.[82] So while many within the Society may have been comfortable with questioning the utility of occult qualities, they did not necessarily agree with the methods pioneered by those, like Cabeo, who stood at the forefront of the investigation of nature's secrets.

[81] *Ordinatio pro studiis superioribus* (1651), p. 27: "Plures sunt primae qualitates sensibiles elementorum, quàm quatuor."

[82] Pumfrey, "Neo-Aristotelianism and the Magnetic Philosophy," p. 184.

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Chapter 4

Spectacle, Uncertainty, and the Fallibility of the Eye

Two years after Niccolò Cabeo's work on the magnet appeared in print, a young and ambitious German Jesuit reached the city of Lyons. That he arrived there at all was, to his mind, something of a miracle, for to do so he had first to survive the perilous uncertainties of travel through the chaos and bloodshed of the Thirty Years War. Fleeing ahead of advancing Protestant armies, Athanasius Kircher reached Lyons somewhat the worse for wear, but he soon recovered and made his way to Avignon and then to Aix. He quickly established himself as an energetic and erudite naturalist with a penchant for spectacular displays and an uncanny knack for languages. Two years later, in 1633, he was summoned first to Vienna and then to Rome to serve as professor of mathematics in the Jesuit house of learning, the Collegio Romano.[1]

While in France the young Kircher confirmed his intellectual credentials first by producing a rare Coptic manuscript that he claimed to have rescued from the disintegrating remnants of the Palatinate, and then by displaying his wondrous *horoscopium botanicum*, a kind of living sundial constructed from a single sunflower. Before this, while in Mainz, Kircher had already demonstrated that the seeds of another heliotropic plant, a nightshade, would follow the course of the sun when affixed to a cork floating in a basin of water, a demonstration he then repeated at Avignon and Aix.[2] He further heightened the esoteric nature of these demonstrations by describing to his audiences, both at these demonstrations and, later, in his 1641 *Magnes; sive, De arte magnetica*, how he

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[1] Portions of this chapter appeared originally in Mark A. Waddell, "A Theater of the Unseen: Athanasius Kircher's Museum in Rome," in *A World Such As This I Dreamed: Cosmogony in the Early Modern Mind*, ed. Allison B. Kavey (New York: Palgrave Macmillan, 2010), pp. 67–90. Reproduced with permission of Palgrave Macmillan. The full published version of this essay is available from http://www.palgraveconnect.com/pcdoifinder/10.1057/9780230113138.

[2] Paula Findlen, "The Last Man Who Knew Everything ... Or Did He?," in Findlen, ed., *Athanasius Kircher: The Last Man Who Knew Everything* (New York: Routledge, 2004), p. 13.

Figure 4.1 Athanasius Kircher at the age of 76.
Source: Courtesy Department of Special Collections, Stanford University Libraries.

had purchased these marvelous seeds from an Arabic merchant in Marseilles in exchange for a clock so small it was part of a ring.[3]

In a sense, Kircher's botanical clock was the wondrous and spectacular fruit of Cabeo's earlier magnetic investigations. As witnessed by bemused and marveling audiences, the sunflower—floating on a cork platform in a basin of water—rotated slowly over the course of an entire day, even after the sun had set (and thereby appearing to prove the reality of a geocentric cosmos). In his *Magnes* Kircher boasted that his device had "captured the greatest delight of many," but while

[3] Athanasius Kircher, S.J. *Magnes; sive, De arte magnetica*. 1st ed. (Rome, 1641), p. 737.

he waxed eloquent about the occult correspondence between the plant and the sun that drove this amazing display, the reality may have been more prosaic. His *Magnes* revealed that at least one other clock in Kircher's collection, which he presented as powered entirely by magnetism, was actually a water-clock that incorporated small, hidden magnets only in an incidental fashion, and Kircher's friend and patron Nicolas-Claude Fabri de Peiresc (1580–1637), who witnessed the young Jesuit's spectacular demonstrations in Avignon, suspected that some of these wondrous clocks were, in fact, clever tricks.[4] This was a kind of "magnetic" demonstration the likes of which Cabeo had never contemplated, but whether an example of trickery or not, it was also a demonstration guaranteed to intrigue and provoke audiences. It was with his wondrous sunflower clock, and other spectacles like it, that Kircher embarked on a path that would make him one of the most well-known and controversial thinkers of his day.

Kircher's fondness for spectacle and his eclectic philosophy of nature marked him as an innovative (if bemusing) thinker, but it was the museum that he established in Rome that truly set him apart from his contemporaries. It was an entire world unto itself, an elaborate and bewildering cosmos that existed nowhere else in early modern Europe. In its heyday, the museum was an intellectual and spectacular marvel, visited by popes, cardinals, and princes as well as a host of intellectual luminaries from both sides of the confessional divide. A visit to Rome by the virtuosi of Europe inevitably included a sojourn in Father Kircher's wondrous collection, and Kircher himself once boasted, "No foreign visitor who has not seen the museum of the Collegio Romano can claim that he has truly been in Rome."[5] For the historian, this collection offers an intriguing glimpse of Kircher's wide-ranging and sometimes chaotic epistemology. It was a visual and tangible expression of the principles that governed his pursuit of knowledge, but it was also inherently ephemeral—its fortunes were closely tied to Kircher himself and, as he declined, so too did his collection. It disintegrated swiftly following his death, in spite of efforts to preserve it in the early years of the eighteenth century.

Kircher was not, however, a simple collector of natural marvels. He was an active world-builder whose museum demonstrated his strong interest in how we come to know things about the universe. The Kircherian collection did more than display tantalizing hints of nature's secrets, as some have suggested;

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[4] Koen Vermeir, " 'Bent and Directed Towards Him': A Stylistic Analysis of Kircher's Sunflower Clock," in Ofer Gal and Raz Chen-Morris, eds., *Science in the Age of Baroque* (Dordrecht: Springer, 2013), pp. 49–51.

[5] Paula Findlen, "Scientific Spectacle in Baroque Rome: Athanasius Kircher and the Roman College Museum," in Mordechai Feingold, ed., *Jesuit Science and the Republic of Letters* (Cambridge, MA: MIT Press, 2003), p. 225.

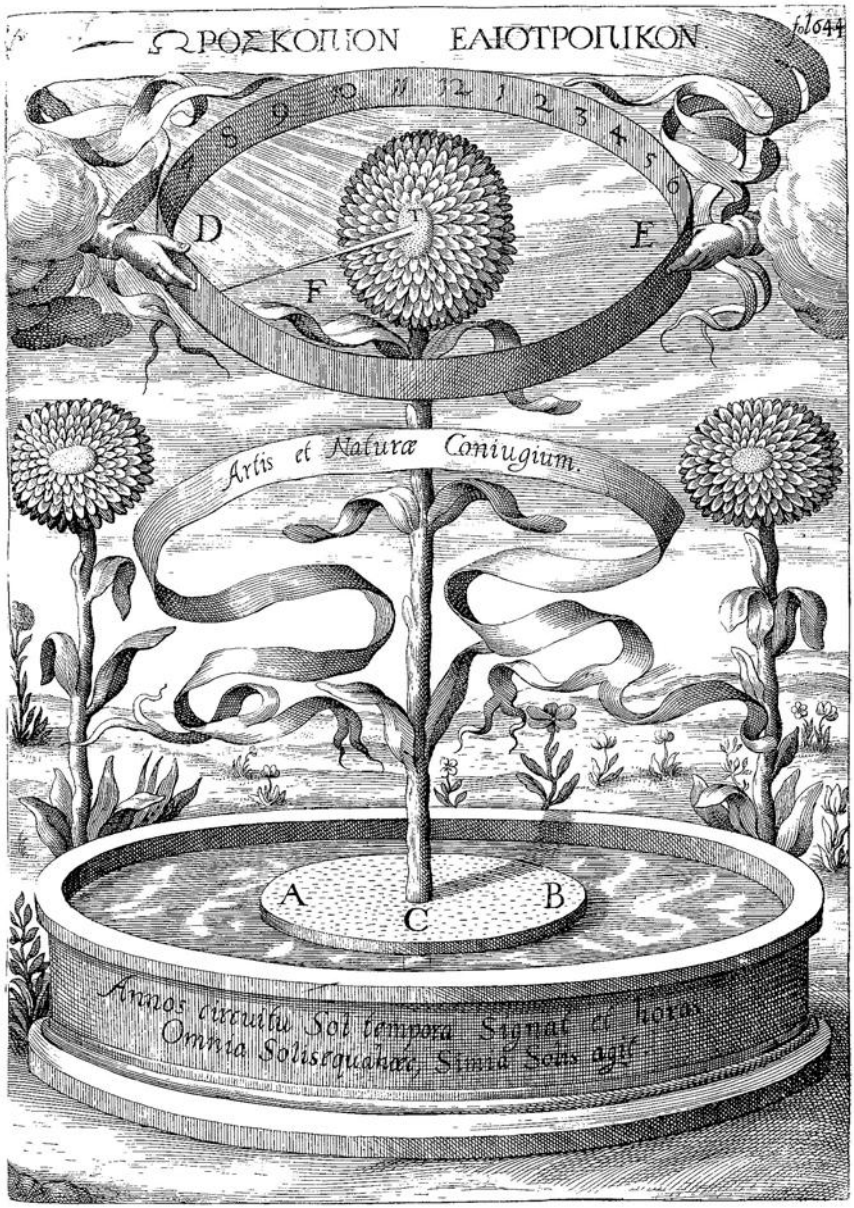

Figure 4.2 Kircher's sunflower clock, labeled as "the marriage of art and nature," from his *Magnes; sive, De arte magnetica*.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

it also displayed the methodological keys required to unlock those secrets. It trained its audiences in "how to see," an exercise mediated in this case by the intervention of artifice, even as it pointed to the fallibility of their senses. Thus, the central core of the collection was concerned less with accumulation and more with querying the act of knowing.

In important ways, the Kircherian collection embodied the values and preoccupations of baroque Rome: its playful use of spectacle and illusion, its persistent rhetoric of mystery, and its participation in the vibrant culture of natural and artificial magic all linked the museum to key aspects of life in Rome around the middle of the seventeenth century. At the same time, however, the collection also embodied important epistemological changes that were sweeping through the Society of Jesus. In its attention to the use of apparatus and artifice, the collection embraced the disciplines of mixed mathematics and, perhaps, anticipated the culture of machines that would come to prevail in the Royal Society under the auspices of Boyle, Hooke, and others. In its public character it emphasized the necessity for universal assent—still crucial to the Aristotelian process of knowing—while its crowded galleries of spectacular machines and philosophical puzzles called attention to the singular, subjective experience. It both challenged and celebrated the exercise of the senses, blurring the already fraught boundary between sensualism and skepticism. Most importantly, in its rhetorics of similitude, spectacle, and correspondence the collection encouraged probable considerations of natural phenomena rather than offering certain and evident demonstrations of causes.

The Kircherian museum thus offers another window on the ways in which some early modern Jesuits struggled to respond to the crisis of certainty. The world presented by Kircher was a theater of the unseen, simultaneously a celebration and a revelation of the hidden parts of nature. This almost paradoxical identity resulted in a space that functioned somewhere between spectacle and instruction, bemusement and enlightenment. Indeed, "bemusement" seems a good term to apply to this collection: Kircher wanted his audiences to be hesitant, overwhelmed, confused—in a word, uncertain. Only then could he instruct them in new and more powerful ways of understanding the hidden secrets of the world.

Situating Collection and Curator

The past decade or more has seen considerable scholarly interest in the life and works of Athanasius Kircher, and yet historians have tended to approach him

with a certain ambivalence, as if unsure how, exactly, to characterize him. The predominant view portrays him as an eccentric polymath, an encyclopedic collector with an overly credulous mindset and a penchant for the bizarre and the mysterious, interesting as a throwback to the Renaissance, as an anachronism, but not as a progressive thinker with his feet firmly planted in the intellectual culture of the seventeenth century.[6] This characterization may have its roots in the attitudes of Kircher's contemporaries, who evinced an ambivalence of their own when it came to the relative worth of his ideas. As but one example, consider the words of Henry Oldenburg, who, tongue firmly in cheek, wrote to Robert Boyle in 1658 of "an excursion into Italy and there to bring you news of the industrious Kircher's subterranean world, his strange grotto *de' serpi*, his story of the growth of pulverized and sown cockles, irrigated by sea-water, his thermometer by a wild oat's beard, his vegetable phoenix's resurrection out of its own dust by the warmth of the sun: his pretended ocular confutation of Kepler's magnetical motions of the planets about the sun: and of Gilbert's magnetical motion of the earth, and of twenty other remarkable things one might yet have the satisfaction to be punctually informed about."[7]

The Kircherian collection of which Oldenburg wrote with such amusement was actually the descendent of another philosophical collection already housed in the Collegio, the "mathematical museum" of Christoph Clavius and his student Christoph Grienberger. Kircher's collection took shape in the 1630s and was housed originally in his own apartments in the Collegio, but in 1651 he expanded it with the addition of another collection, that of the Roman patrician Alfonso Donnino, and moved it to a larger and more public space. At the time it was merely the latest in a long line of collections and theaters of nature located in the Eternal City, but its identity as a public showpiece for the Society of Jesus and, more particularly, for Kircher himself soon made it a unique and much-visited space in baroque Rome.

It is true that in at least some respects the Kircherian museum was typical of its time, with its juxtaposition of *naturalia*, antiquities, and artwork. It was primarily in the element of bemusement, however, that this museum differed from other, contemporary collections. While those other collections typically demonstrated the erudition or wealth of their owners as well as organized or

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[6] See, for example, John Edward Fletcher, *A Study of the Life and Works of Athanasius Kircher, 'Germanus Incredibilis'* (Leiden: Brill, 2011), esp. ch. 5; John Glassie, *A Man of Misconceptions: The Life of an Eccentric in an Age of Change* (New York: Penguin, 2012); Joscelyn Godwin, *Athanasius Kircher's Theatre of the World: The Life and Work of the Last Man to Search for Universal Knowledge* (Rochester, VT: Inner Traditions, 2009).

[7] Oldenburg to Boyle, 29 March 1658, as cited in Fletcher, pp. 132–3.

systematized the world in a way that permitted investigation and understanding, the Kircherian museum, while advertising the resources and accomplishments of the Jesuit order, became primarily an expression of Kircher's unique worldview. He used his collection to portray the world as fundamentally mysterious, crisscrossed by invisible forces that only his carefully orchestrated philosophical displays could reveal. At the same time, he used these displays to instruct his audiences in the fallibility of their senses, the ease with which their eyes could be tricked and their vision of nature distorted.

Paula Findlen has described Kircher himself as his museum's most spectacular exhibit.[8] In deliberately exploiting the bemusement of his audience, however, Kircher also fashioned for himself a powerful role as mediator and guide. In the production and consumption of spectacle there is always an exchange of power: a willingness on the part of the audience to reveal, and to revel in, their ignorance of the principles behind the spectacular displays, and a concomitant assertion of virtuosity and mastery on the part of the wonder-worker—mastery, that is, over the audience itself as well as over the physical principles that make his marvels possible. In wrapping his philosophical principles in spectacular displays and a playful extravagance, Kircher confirmed his own mastery even as he beguiled and instructed his visitors.

Findlen in particular has characterized Kircher's virtuosity in terms of the encyclopedic accumulation of objects and ideas, and his museum as an "illustrated encyclopedia"[9] whose "primary function ... lay in the identification of *signs*."[10] This emphasis on the "accumulation of objects and publications" reinforces a characterization of Kircher as "the embodiment of a new form of expertise—not the 'on-site' knowledge of the traveler but the more synthetic knowledge of the collector whose wisdom surpassed the abilities of any one individual."[11] In line with such a characterization is the suggestion that "one of the preconditions for the circulation of beliefs concerning wonders of nature and art is that one accepts one's source as being a passive conductor of information, a disinterested mediator of knowledge," [12] which presents the

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[8] Michael John Gorman, "From 'The Eyes of All' to 'Usefull Quarries in philosophy and good literature': Consuming Jesuit Science, 1600–1665," in *The Jesuits: Cultures, Sciences, and the Arts, 1540–1773*, John W. O'Malley, S.J., Gauvin Alexander Bailey, Steven J. Harris, and T. Frank Kennedy, S.J., eds. (Toronto: University of Toronto Press, 1999), p. 179.

[9] Findlen, "Scientific Spectacle," p. 240.

[10] Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994), p. 84.

[11] Findlen, "Scientific Spectacle," p. 229.

[12] Gorman, "From 'The Eyes of All'," p. 171.

passive and disinterested Kircher as exemplifying the courtly ideal of *sprezzatura* in which virtuosity and disinterestedness went hand in hand, and which locates the Kircherian collection more firmly in courtly culture.[13]

There is evidence, however, that Kircher saw his own role to be that of an active disseminator of ideas rather than a passive collector. His disciple Giorgio de Sepi confirmed as much in 1678 when he published a catalogue of the Kircherian collection: the *Romani Collegii Societatis Jesu Musaeum Celeberrimum*, or "The Most Celebrated Museum of the Roman College of the Society of Jesus." In its preface, De Sepi concluded by saying, "The workshop of Art and Nature, the treasury of the mathematical disciplines, the epitome of philosophical practice—this is the Kircherian museum."[14] His use of the word "workshop" (*ergasterium*) implied activity rather than passivity, and the collection's identity as a "treasury" (*gazophylacium*) of the (mixed) mathematical disciplines was undoubtedly rooted in its culture of machines. More significant, however, was his use of the phrase "philosophical practice." According to De Sepi, Kircher did not envision his museum as a simple repository for objects but as, instead, a tangible demonstration of how best to practice natural philosophy. Its purpose was explicitly both epistemological and practical.

The characterization of Kircher as merely passive or encyclopedic also leaves little room for those who visited his collection. His entire philosophical endeavor, however, both within his museum and in the texts that he published beyond its walls, depended absolutely upon the cooperation of spectators. Lacking the collective observation of an audience, the museum itself was indeed merely an accumulation of objects. While Findlen has suggested that the lodestone or magnet acted as the "key" to the Kircherian museum,[15] I would suggest instead that the true key to the collection was its audience. In an important sense, it was only the attention of its visitors that made possible the collection's efficacy as an expression of both the world and the practice of studying it. Without an audience, the museum failed to work as intended.

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[13] Gorman himself suggests a connection with the ideal of *sprezzatura*: see his "Between the Demonic and the Miraculous: Athanasius Kircher and the Baroque Culture of Machines," in Daniel Stolzenberg, ed., *The Great Art of Knowing: The Baroque Encyclopedia of Athanasius Kircher* (Stanford: Stanford University Libraries, 2001), p. 62.

[14] Giorgio de Sepi, *Romani Collegii Societatis Jesu Musaeum Celeberrimum* (Amsterdam: Ex Officina Janssonio-Waesbergiana, 1678), *Praefatio ad Curioso Lectori*: "Artis itaque & Naturae ergasterium, disciplinarum Mathematicum gazophylacium, philosophiae practicae epitomen, Musaeum Kircherianum hisce. "

[15] Findlen, *Possessing Nature*, p. 85.

The central role of the audience is communicated clearly in the De Sepi catalogue. On its frontispiece, we see Kircher speaking with a pair of visitors, presumably greeting them as they enter; the letter with which he has been presented is probably an introduction. The tableau, and particularly the letter, are themselves expressions of the carefully regulated social conventions that dictated such encounters. It captures as well the important fact that it was Kircher who met with and guided his visitors. There were no unaccompanied strolls through the collection, and as a result the museum provided an excellent opportunity for Kircher to present his idiosyncratic view of the world to a select but influential public.

The description presented by the De Sepi catalogue reflects as well the reality of the Kircherian museum as a public space, and indicates that it was in its very "public-ness" that its purpose resided. Before this, collections usually had existed in the private homes of their collectors, a trend that began to change in the sixteenth and seventeenth centuries. Kircher's own collection initially was confined to his apartments in the Collegio Romano, but following its expansion in 1651 it lost this sense of personal intimacy and became, instead, something larger, more public, and considerably more effective as a demonstration of the Society's resources and erudition. Indeed, the eventual fate of the collection testifies to the integral link between "public-ness" and purpose: towards the end of Kircher's life his museum came to occupy a dark and narrow corridor in the Collegio, a far cry from the vaulted, lavishly decorated gallery of its heyday. Thus, as the personality behind the collection waned along with its prestige, so too did its exposure; its utility was directly proportional to its public character.

Both audience and "public-ness" were, in fact, central to the collection's identity as "the epitome of philosophical practice," as De Sepi phrased it. As a series of public demonstrations, the Kircherian collection may have embraced at least a nominally Peripatetic orientation, particularly in its attention to the line between singular and collective experiences. As we have already seen, the philosophy of Aristotle considered an explanation for natural phenomena as "evident" only insofar as it met with collective assent, which created problems for astronomers such as Christoph Scheiner and Giovanni Battista Riccioli (1598–1671) and their efforts to present individual observations as credible sources of knowledge. These individuals, and others like them, sought a sort of middle ground, a series of strategies whereby Jesuits collected and collated singular experiences into something that approached universal assent.[16]

[16] For examples of such strategies in the work of Riccioli, see Janet Vertesi, "Picturing the Moon: Hevelius's and Riccioli's Visual Debate," *Studies in History and Philosophy of*

Many of the machines and puzzles that filled the Kircherian museum also encouraged the consideration of singular experiences. That these elaborate displays permitted public contemplation, however, transformed them into something closer to a collective or universal experience, as did the deliberate repetition of magnetic and optical devices within the collection. François d'Aguilon (1567–1617) and Louis Bertrand Castel (1688–1757), Jesuit philosophers who together bracketed Kircher's own time in the Society, both argued that "the repetition of many [singular] acts," each exhibiting the same behavior, could in itself create the conditions necessary for collective or universal assent.[17] This may explain why Kircher displayed not just one or two magnetic machines, but a dozen or more: alone, each demonstrated the basic behavior of the magnet, but together, all of them functioned collectively to make that behavior "evident" in the philosophical sense. Thus, both the collection's public identity and the active participation of its audiences were integral to establishing its philosophical legitimacy, at least in an Aristotelian context.

For all of its attempts to establish this legitimacy, however, the Kircherian collection still presented audiences with a world that remained mysterious and largely inscrutable. Even if the occult forces pervading the universe were rendered visible, Kircher's visitors could not have found their revelation an altogether easy experience; after all, witnessing such forces is not the same thing as understanding them. It is also true, however, that the display and manipulation of these occult forces fell squarely within the traditions of natural and artificial magic, and for those living in seventeenth-century Rome this carried a host of associations and potential problems that Kircher's collection could not escape entirely.

Magic and Mysteries: The Roman Context

We have already seen that, for many early modern thinkers, natural magic was in many respects indistinguishable from the study of nature. Giambattista della Porta, whom Cabeo mentioned in the early pages of his *Philosophia magnetica* as one who had written on the magnet, discussed natural magic as a kind of practical philosophy, focused on the production of specific effects, and proclaimed that it "openeth unto us the properties and qualities of hidden

Science Part A, vol. 38 (2007), pp. 401–21; Alfredo Dinis, "Giovanni Battista Riccioli and the Science of His Time," in Mordechai Feingold, ed., *Jesuit Science and the Republic of Letters* (Cambridge, MA: MIT Press, 2003), pp. 195–224.

[17] Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), p. 19.

things, and the knowledge of the whole course of Nature."[18] In the Jesuit college at Coimbra, numerous commentators affirmed that "the manipulation of natural occult forces was entirely legitimate"[19] and discussed natural magic as little more than applied physics.[20] Kircher himself wrote in his *Magnes*, "I call natural magic that which, excluding all commerce with the enemy of the human race, whether implicit or explicit, produces prodigious and unseen effects by solely natural causes, through the combination of various applications."[21] One would be hard-pressed to find definitions of natural magic that varied from these commonplaces, at least among the mainstream of early modern thinkers, though different people sometimes ascribed more efficacy, sometimes less, to magic in general. Virtually everyone agreed that magic was merely the manipulation of natural—usually hidden—forces in order to produce specific effects.

It is also true that magic was "an essential part of Roman Baroque culture" in a way that it was not throughout most of Europe in the seventeenth century.[22] The varied and powerful beliefs of the urban poor mirrored in many respects the learned disquisitions on astrology, alchemy, and *magia naturalis* that circulated among the Roman elite in this period, and even members of the clergy were sometimes implicated in the practice of magic, particularly that of the "black" variety. Two years after Kircher first arrived in Rome, several individuals were punished, imprisoned, and even executed for the illicit use of magic; some were aristocrats, others were priests accused of attempting to murder pope Urban VIII by magical means.[23] Indeed, so worried was Urban by these ostensible threats on his life that he enlisted the aid of Tommaso Campanella (1568–1639), and together they employed an arcane combination of music, words, and symbols to ward off the astrological influences that Urban believed were threatening his health.[24]

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[18] Giambattista della Porta, *Natural Magick* (London, 1669), p. 2.

[19] Brian Copenhaver, "The Occultist Tradition and its Critics," in Daniel Garber and Michael Ayers, eds., *The Cambridge History of Seventeenth-Century Philosophy*, Volume I (Cambridge: Cambridge University Press, 1998), p. 458.

[20] Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Oxford University Press, 1997), p. 230.

[21] Kircher, *Magnes*, 2nd ed. (1643), p. 286: "Magiam naturalem hoc loco eam voco, quae excluso omni cum humani generis hoste commercio, quà implicito, quà explicito, ex solis naturalibus causis per variae applicationis combinationem invisos & prodigiosos effectus producit ... "

[22] Peter Rietbergen, *Power and Religion in Baroque Rome: Barberini Cultural Policies* (Leiden: Brill, 2006), p. 337.

[23] Rietbergen, pp. 347–9.

[24] Rietbergen, p. 336.

Thus, it is not difficult to appreciate how discussions about magic fit into the wider fabric of life in baroque Rome. It could excite controversy, but it was also integral to many discussions about the natural world. Imagine, then, a young Kircher, fresh from his triumphs in Aix and Avignon, entering Rome at the very moment when the city all but seethed with magical intrigues. He quickly would have understood that conflicting and powerful currents swirled around the exercise of magic and other arcane arts; for a young and ambitious Jesuit, it was a cultural context ripe with possibilities. With his botanical clock and his magnetic machines, he was able to appeal to a wide range of learned audiences, though some who watched small statues move silently and mysteriously across a stage (thanks to magnets hidden beneath the platform) no doubt wondered whether Kircher had secured the aid of demons in order to produce such spectacles, just as the Knights of Malta had once accused him of trafficking with infernal powers after Kircher designed and built a magnetic anemoscope to foretell changes in the wind. Others, however, would have applauded these spectacles as nothing more than the ingenious application of natural forces, and indeed may have done so in the context of courtly "games" whereby the informed could exhibit their erudition by exposing Kircher's mysteries as clever examples of artificial magic.[25]

There were other elements of Kircher's thought that may have encouraged contemporaries to view him as more magus than philosopher. He had a keen interest in all things Egyptian, and wrote passionately about the *prisca theologia*, the first and most pure form of theology, contained in the recovered writings of the Egyptian magus *par excellence* Hermes Trismegistus as well as in the physical remains of Egyptian culture scattered throughout baroque Rome.[26] His philosophy of nature was sometimes more Neoplatonic in tone than it was Aristotelian or Peripatetic, and he embraced both an intellectual eclecticism and a commitment to universalism that guided much of his research into the structure of the world. In all of these respects, however, Kircher was far from exceptional. Interest in Egypt was widespread in Rome from the earliest decades of the sixteenth century, and the purported writings of Hermes continued to inspire a range of Catholic thinkers for many decades after Isaac Casaubon demonstrated, in 1614, that the Hermetic corpus was not a product of antiquity after all.[27] Neoplatonism, too,

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[25] See Gorman, "Between the Demonic and the Miraculous."

[26] On Kircher's fascination with ancient Egypt and the tradition of *prisca theologia*, see Daniel Stolzenberg, *Egyptian Oedipus: Athanasius Kircher and the Secrets of Antiquity* (Chicago: University of Chicago Press, 2013).

[27] Brian Curran, *The Egyptian Renaissance: The Afterlife of Ancient Egypt in Early Modern Italy* (Chicago: University of Chicago Press, 2007).

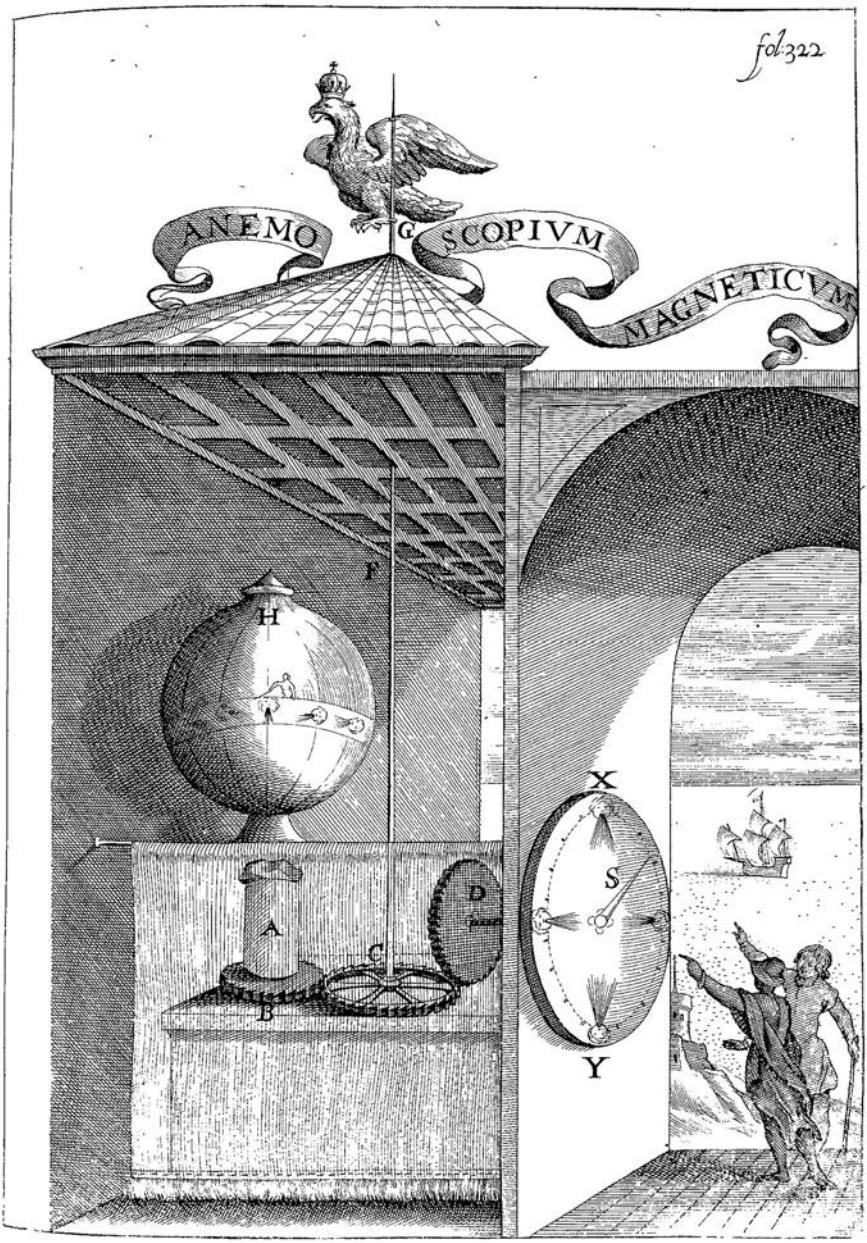

Figure 4.3 Kircher's magnetic anemoscope that he constructed on Malta, from his *Magnes; sive, De arte magnetica.*

Source: Courtesy Department of Special Collections, Stanford University Libraries.

was an integral part of Roman culture, inspiring some of the finest examples of baroque art and architecture throughout much of the sixteenth and seventeenth centuries.[28] If these things are markers of magical predilections, then seventeenth-century Rome must have overflowed with magicians.

However contemporaries viewed Kircher's work, it is true that he did not ignore or dismiss the wider subject of magic. He discussed natural magic in his 1641 work on the magnet, and he did so again in his *Ars magna lucis et umbrae* of 1646 in which he divided magic into "contemplative" and "effective," a standard distinction among early modern Aristotelians.[29] Contemplative magic, he wrote, was the consideration of nature's hidden secrets, a practice that he linked with both Theophrastus and Aristotle. Thus, contemplative magic was comparable to natural philosophy in its broadest strokes, particularly in the Peripatetic sense, concerned with the investigation of such hidden, inward intangibles as form and essence.[30] Historians have focused on this particular branch of magic in their discussions of Kircher as a "connoisseur of magic," drawing parallels between the Jesuit father's interest in the occult operations of nature and both his fascination with the Egyptian mysteries and the wider culture of wonders and marvels then prevalent throughout Europe.[31] Yet, after offering his definition of contemplative magic in the *Ars magna lucis et umbrae*, Kircher stated explicitly that the focus of his work was effective or practical magic: "The other [type of magic] is the fashioning [*effectrix*] of unusual works, of which sort we display in this book."[32] One finds this same emphasis in many of his other natural philosophical works, including the *Magnes* (1641), the *Mundus subterraneus* (1664/5), and the *Phonurgia nova* (1673). In every case, one finds relatively little in the way of mystical digressions or occult philosophizing but, instead, repeated references to a "magic" that aimed to investigate the hidden secrets of nature by manipulating the world in specific, controlled ways, often mediated by artifice and experiment.

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[28] For example, John Hendrix, "Neoplatonism in the Design of Baroque Architecture," in Aphrodite Alexandrakis and Nicholas J. Moutafakis, eds., *Neoplatonism and Western Aesthetics* (Albany: SUNY Press, 2002).

[29] Athanasius Kircher, S.J., *Ars magna lucis et umbrae, in decem libros digesta* (Rome: Hermanni Scheus, 1646), p. 769: "[Magiam] duplicem statuimus: unam contemplatricem, effectricem alteram."

[30] Kircher, *Ars magna lucis et umbrae*, p. 770: "Contemplatrix Magia, rerum in arcana naturae majestate penitus abditarum secretior quaedam, & abstrusior sapientia est."

[31] Daniel Stolzenberg, "The Connoisseur of Magic," in Stolzenberg, ed., *The Great Art of Knowing: The Baroque Encyclopedia of Athanasius Kircher* (Stanford: Stanford University Libraries, 2001), pp. 49–58.

[32] Kircher, *Ars magna lucis et umbrae*, p. 770: "Alia effectrix operum inusitatorum, cuiusmodi nos in hoc libro proponimus ... "

Kircher described this practical or effective magic as the production of unusual effects that one could not explain easily without a sufficient knowledge of natural mysteries.[33] Again, this was a standard definition for the time. Martín del Rio, that acknowledged expert on all things magical, conflated "operative" and "artificial" in his definition of *magia artificiosa* in the *Disquisitionum magicarum libri sex* of 1599. He then divided artificial or effective magic in two: *Mathematica* and *Praestigiatoria*. The former, mathematical branch "depends upon the principles of geometry, arithmetic, or astronomy," while the other, which he called *Praestigiatrix*, was concerned with things "ludicrous and deceptive," as in machines that, though they appear to be operated by incantations, actually worked by the "agility of the foot or the hand."[34]

Almost fifty years after the publication of Del Rio's *Disquisitionum magicarum*, Kircher's own discussion of effective magic in the *Ars magna* sounded remarkably like that of his fellow Jesuit. He, too, assigned a mathematical character to this branch of magic, providing a list of disciplines that combined the traditional *quadrivium* of the schools with examples of mixed mathematics: "Musica, et caeterae Mathematicae, Geometria, Arithmetica, Statica, Optica, Astronomia."[35] This was not a Neoplatonic or even quasi-Pythagorean paean to the mystical power of numbers, however. As Kircher explained, such disciplines lent themselves to the production of astounding effects because they were so little understood. An audience could view a particular phenomenon as "magical" (or, importantly, have a phenomenon presented to them as such) if it excited bemusement or confusion and thus appeared wondrous or astonishing. What defined something as magical, then, was the relative ignorance of the audience, not the philosophical pretensions of the would-be magician.

Audiences accepted the sunflower clock and Kircher's magnetic machines as examples of magic—whether natural or artificial—because with them he appeared to manipulate a natural but invisible force; that these audiences were ignorant of any hidden mechanical apparatus only made the demonstration more wondrous. Moreover, if the perception of "magic" was contingent upon the ignorance of one's audience, then Kircher's museum in Rome was the perfect venue in which to control and channel that ignorance, making it in turn an important locus in baroque Rome for the practice of magic. Thus, obfuscation and mystery were integral to the Kircherian philosophy of nature. So, too, was

[33] Kircher, *Ars magna lucis et umbrae*, p. 770: "adeo insolitos effectus proferunt, ut nemo eorum facilè rationes, nisi mysteriorum oppidò gnarus, assignet."

[34] Martín Antonio del Rio, S.J., *Disquisitionum magicarum libri sex, in tres tomos partiti* (Louvain, 1599–1600), pp. 42–3.

[35] Kircher, *Ars magna lucis et umbrae*, p. 770.

spectacle, which also occupied a key role in contemporary Roman culture. Indeed, it is difficult to imagine the Kircherian museum existing anywhere else; its principles and ideals were aligned with exquisite precision with those of the Eternal City as it existed in the seventeenth century. In its fixation on obfuscation and visual trickery, the Kircherian collection embodied the quintessentially baroque obsession with *trompe l'oeil*, anamorphism, and other kinds of illusionistic art.[36] At the same time, through his collection Kircher participated in the increasingly public culture of demonstration and experiment in which the Jesuits were especially prominent: the displaying of mathematical and mechanical demonstrations in and around the Collegio Romano confirmed the intellectual status of the Jesuits while dovetailing neatly with the importance of public life in Rome.[37]

The Kircherian collection reflected its local culture in other ways as well. We already know that baroque Rome was obsessed with the remnants of ancient Egypt; between the latter decades of the sixteenth century and the middle of the seventeenth, no fewer than five Egyptian obelisks were erected or relocated throughout the city under the auspices of various popes. Obelisks were also to be found in Kircher's museum, and Egyptian sensibilities played an important role in the lavishly choreographed visits of Queen Christina of Sweden to the Collegio Romano. Having converted to the Catholic faith and abdicated her throne, her arrival in Rome in 1655 was heralded by a series of sumptuous displays, spectacles, and other public events. When she made two visits to the Collegio in January of 1656, Kircher pulled out all the stops: he cast her as "Isis reborn" and presented her with a model of an obelisk "inscribed with arcane characters of the ancient Egyptians" and dedicated "to the great Christina."[38] He demonstrated, too, what he called his "hermetic experiment," which was described in 1678 by Giorgio de Sepi and, before that, in Henry Oldenburg's letter to Robert Boyle. Supposedly a demonstration of palingenesis or the "vegetable phoenix," in which a plant was reduced to ash from which it was subsequently resurrected, the remnants of this experiment, at least in De Sepi's description, involved nothing more than a sealed vial of ash. What Christina

[36] William Egginton, "Of Baroque Holes and Baroque Folds," pp. 55–71, and David R. Castillo, "Horror (Vacui): The Baroque Condition," pp. 87–104, in Nicholas Spadaccini and Luis Martín-Estudillo, eds., *Hispanic Baroques: Reading Cultures in Context* (Nashville: Vanderbilt University Press, 2005).

[37] Rivka Feldhay, "On Wonderful Machines: The Transmission of Mechanical Knowledge by Jesuits," *Science and Education*, vol. 15 (2006), pp. 151–72.

[38] De Sepi, p. 12: "Magnae Christinae, Isidi redivivae, Obeliscum hunc arcanis, Veterum Aegyptiorum notis inscriptum erigit, dicat, consecrat A.K.S.J."

witnessed, with all its associated moral and religious tropes, was an ephemeral image of the long-dead plant, resurrected on command by Kircher himself.[39]

Whether or not we choose to characterize Kircher as a magician, it is clear that he was enmeshed deeply in the magical traditions and practices prevalent in seventeenth-century Rome. At the same time, he borrowed inspiration from the wider culture of the city, particularly its focus on art, spectacle, and, by extension, the exercise of the eyes. By blending these things together—the manipulation of occult forces on the one hand, an emphasis on vision and seeing on the other—the Kircherian collection offered a singular opportunity to explore the ambiguities and pitfalls inherent in early modern attempts to study the hidden secrets of the natural world.

The De Sepi Catalogue

There was a curious blurring of lines between museum and text surrounding Kircher's museum, one that began with his published works and continued into the catalogue compiled by De Sepi. It is almost as if the walls of the Collegio Romano simply could not contain the whole of the collection, which consequently spilled over into the world of print.[40] One would have found in the Kircherian museum the same emphases on vision and spectacle that permeated its catalogue as well as Kircher's published works; indeed, it is a relationship between presentation and knowing that seems better-suited to the museum than it does to the text. There are parallels here with the early modern idea of the *museo cartaceo* or "paper museum" favored by naturalists that included Ulisse Aldrovandi (1522–1605) and Cassiano dal Pozzo (1588–1657), and there may exist an important epistemological coherence between collection and text of which Kircher's contemporaries, at least, seemed largely unaware.[41]

More than anything else, the catalogue compiled by Giorgio de Sepi conveys an impression of abundance, a dazzling cornucopia of exotic animals, strange machines, and beautiful pieces of art. Undoubtedly, Kircher intended the museum to awe its visitors with such tangible manifestations of Jesuit influence

[39] J. Marx, "Alchimie et palingenesie," *Isis*, vol. 62 (1971), pp. 275–89.

[40] Adalgisa Lugli, "Inquiry as Collection: The Athanasius Kircher Museum in Rome," *Res*, vol. 12 (Autumn 1986), pp. 109–24.

[41] On the idea of the museo cartaceo, see David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: University of Chicago Press, 2002); Ian Jenkins, "Cassiano dal Pozzo's 'Museo Cartaceo': New discoveries in the British Museum," *Nouvelles de la Republique des Lettres*, no. 2 (1987), pp. 29–42.

and wealth; the spiritual resources of the Society of Jesus were substantial, but their material resources were no less so, as signified by the tributes and *exotica* that flowed into Rome from the whole world. The frontispiece of the catalogue certainly conveys this impression, depicting the museum itself as a beautiful and grandiose space, full of light and existing somewhere between baroque elegance and outright clutter.

In the foreground, Kircher himself greets a pair of guests, an expression of humanist *politesse* that emphasizes the fact that a tour of the museum was inextricably linked with the presence of its administrator. The tiny human figures lend a sense of scale to the collection as well as to the space itself, making both appear truly spectacular. One might interpret this visual diminution of Kircher as a negative commentary on his role in his collection: "Bringing all of nature into the museum, mankind has ultimately been dwarfed in the process. Kircher does not control the objects in his collection; they control him."[42] Ultimately, however, the museum depended absolutely upon Kircher's personal control; without his presence the collection would, and did, disintegrate altogether. It may indeed have dwarfed its visitors with its staggering array of *naturalia*, technologies, and artistry, but the same cannot be said for its controller. The tiny figure of Kircher on the frontispiece makes this point visually, for he stands in the very center of the foreground, his black robes forming a sharp contrast with the pale tiles behind him and thus drawing the eye of the viewer irresistibly to him. The grandeur of the depicted space, then, does not so much dwarf Kircher as bend itself around him; the purpose in depicting this grandeur is to glorify the collection and, by extension, the Society itself, rather than to diminish its curator.

Prominently displayed around Kircher and his guests in the De Sepi frontispiece are several Egyptian obelisks. As De Sepi tells us, there were six altogether, "four large and two small," and they marched along a promenade within the museum, their "Egyptian marks" clearly visible to visitors.[43] Along the walls, De Sepi adds, were a total of thirty-four columns supporting various pieces of marble sculpture and statuary, and in the frontispiece these columns are visible receding away down the central promenade, displaying carved busts in the classical style. To the far left of the image are shelves holding a variety of urns, presumably of ancient provenance, as well as a host of *naturalia*, including what appear to be the three rhinoceros horns mentioned at one point in the catalogue,[44] an elephant's tusk, and, hanging from the ceiling, an animal of uncertain

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42 Findlen, *Possessing Nature*, p. 93.

43 De Sepi, p. 2.

44 De Sepi, p. 30: "Habet *Musaeum* tria *Rhinocerotum Cornua* ... "

Figure 4.4 The Kircherian museum, from the frontispiece to Giorgio de Sepi's *Romani Collegii Societatis Jesu Musaeum Celeberrimum* (1678).

Source: Courtesy Department of Special Collections, Stanford University Libraries.

provenance: it could be the obligatory stuffed crocodile that no early modern collection of natural curiosities could be without (Kircher apparently owned two of them, with one sent all the way from Java), or perhaps it is the same curly-lipped armadillo that Bernini included as part of his *Fountain of the Four Rivers* in Rome's Piazza Navona.[45] A human skeleton towers in the shadows nearby, possibly signifying both anatomical demonstration and the sober reflection of the *memento mori*. Paintings decorate the walls—De Sepi tells us that they depicted popes, Holy Roman Emperors, and other princes of repute as well as important members of the Society of Jesus, including Christoph Clavius, "the incomparable mathematician"—and though obvious pieces of technology are largely absent from this image, a device at the far right, hanging next to a window, is probably some sort of thermometer (or, as De Sepi called it, a "thermoscope").

This depiction portrays a fairly standard seventeenth-century collection, albeit on a grander scale than those of Cesi or Aldrovandi. Natural curiosities stand next to antiquarian pieces, works of art, and examples of artifice in a seeming hodgepodge that looks, to modern eyes, hopelessly confused. In fact, the Kircherian collection, with its exuberant intermingling of objects and categories, frequently blurred ontological and aesthetic boundaries as it brought together the natural, the artificial, and the supernatural in novel and surprising ways.

The frontispiece provides us with a visual approximation of the space occupied by the collection; the text that follows allows us to imagine that we have stepped into the museum ourselves. As we entered, De Sepi tells us that we would have found to our right a library "stuffed [*refertum*] with the works of unique authors" that included a rare manuscript copy of Avicenna's treatise on plants in Latin, Hebrew, and Arabic. To the left was "a wide revolving platform with many rare coins of twelve Roman emperors. … This is followed by a table absolutely crammed [*refertissima*] with lapidary arts, and with sculpture."[46] De Sepi's choice of language—"stuffed with works," "absolutely crammed"—was surely significant, for in these first sentences he conveyed an impression not merely of abundance but, in fact, of there being almost too many things, of shelves and tables that were barely sufficient to contain and display their collections.

This impression is only strengthened by what follows: namely, some sixty pages of lists and descriptions, reeled off with a brisk efficiency. There are

[45] De Sepi, p. 25. On the armadillo, see Eugenio Lo Sardo, *Athanasius Kircher: il museo del mondo: macchine, esoterismo, arte* (Rome: De Luca, 2001), p. 13.

[46] De Sepi, p. 1: "Ad dexteram latus Bibliothecium solius authoris operibus refertum conspicitur … Ad sinistrum latus pulpitum versatile 12 Romanorum Imperatorum copiosis numismatibus pretiosum … . Quod sequitur lapidariae artis, & sculptoriae refertissima mensa."

hydraulic and "hydrotechnic" machines, many of them clocks, as well as "a crystal globe full of water in which the resurrection of the Savior is represented in the middle of the waters." Also mentioned are an assortment of animals native to the Indies and Mexico, as well as a number of brightly colored birds from Brazil. There were examples of glass artistry and related objects, including four glass vials, "hermetically sealed," containing water from the River Jordan that had remained "uncorrupted" for some sixty years (not, perhaps, the most exciting exhibit in the museum) and a collection of "mathematical instruments" that included astrolabes, armillary spheres, and terrestrial globes.

Arriving next at the magnet, De Sepi launched into a flurry of extravagant phrases, calling it "the prodigy of nature, thaumaturgical wonder, labyrinth of hidden and inscrutable virtues, the innermost part [*medulla*] of the Kircherian museum."[47] De Sepi's rhetorical flourishes here probably expressed the same idea that Kircher had sought to convey with his magnetic machines: the emphasis on "hidden and inscrutable virtues" and the reference to thaumaturgy both pointed to an atmosphere of mystery and obfuscation. What these machines offered to their audiences was not a sober philosophical discussion of the magnet's properties but, rather, a lavish spectacle in which the magnet became a prodigious marvel of nature.

The way in which De Sepi described the magnet supports the notion that it had a special significance for Kircher and, particularly, for his collection. It embodied the invisible correspondences that webbed the universe and tied together disparate things, and this was a theme that Kircher explored in detail in his *Magnes; sive, De arte magnetica* of 1641 and that reappeared in later works as well. When De Sepi called the lodestone the *medulla* of the museum, we are meant to understand that, though these magnetic machines take up only four pages of the catalogue, they played a far more significant role in the life of the museum. Indeed, given this language, we can probably assume that Kircher highlighted the presence of these devices when escorting his visitors through the collection. Likewise, we can assume that the purpose Kircher envisioned for these machines was both different in kind and more significant than what he envisioned for his collections of exotic birds and Roman coins.

By all accounts, the magnetic machines scattered throughout the museum were delightful expressions of baroque spectacle. For example, the first magnetic device in the catalogue featured a miniature representation of Typhon, presented

[47] De Sepi, p. 18: "Magnes subtilium cos ingeniorum, prodigium Naturae, mirabilium thaumaturgus, reconditae virtutis inscrutabilis Labyrinthus, *Kircheriani Musæi* medulla, lapis est."

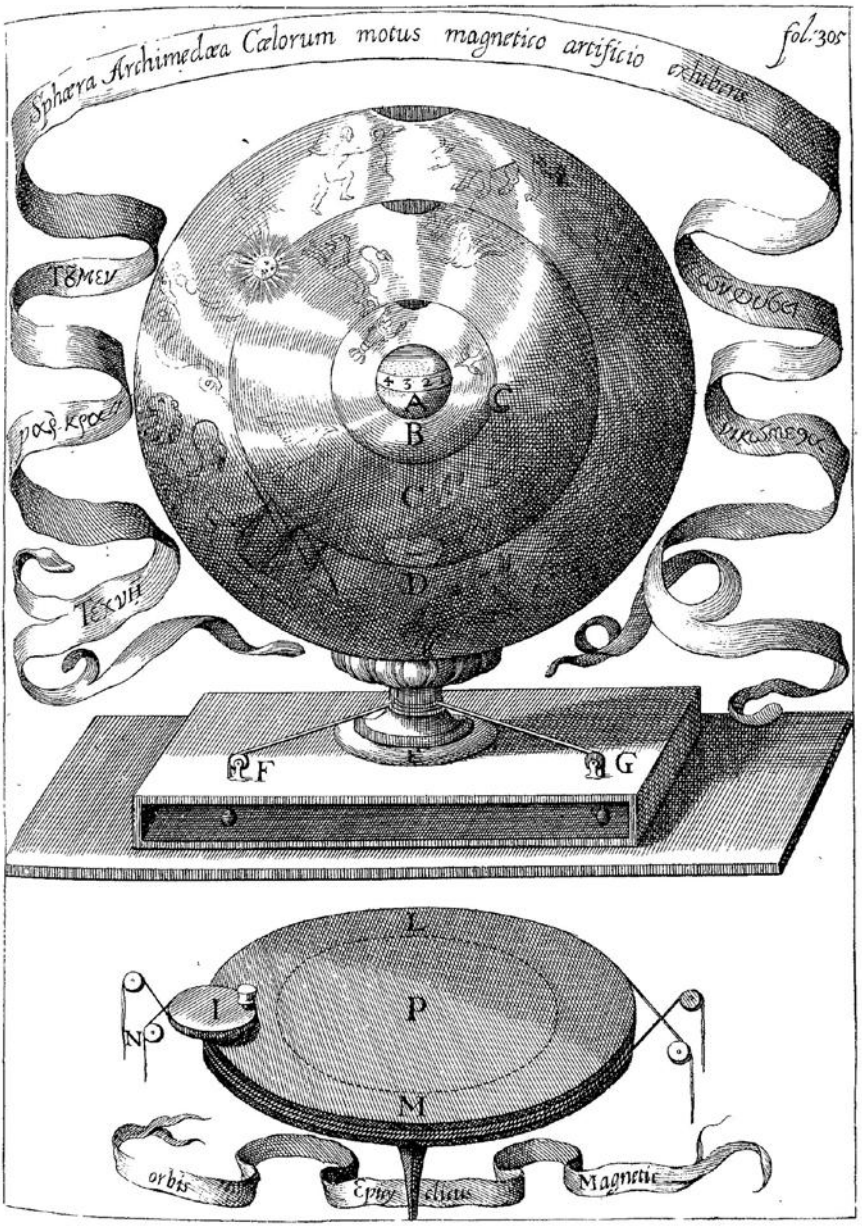

Figure 4.5 The magnetic planetarium of Archimedes, from the *Magnes; sive, De arte magnetica*.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

here as the Greek god of wind, seated at the tiller of a crystalline boat that travelled around a toy sea (*ludicrum mare*) by means of a "secret power" (*arcana vis*), thereby exhibiting a "most pleasing spectacle" to the eyes. The "wind" that propelled the tiny boat was, of course, a small magnet hidden under the water. Other machines instructed those who examined them—"This machine teaches you a new method of finding the meridian line" (*Docet te hæc machina novam praxin inveniendi lineam meridianam*)—while others were reiterations of well-known feats of ancient ingenuity, such as the wooden dove fashioned by Archytas that reputedly could fly. There were models of the geocentric universe that rotated once every twenty-four hours thanks to the guidance of an "occult motion," and De Sepi added that the collection boasted "not one, but three" reproductions of the famous planetarium of Archimedes mentioned by Cicero and other classical authors, displayed on the promenade in the middle of the museum.

The common thread running through these devices was not simply that magnetism drove them, but that Kircher presented them as embodying "secret forces" and "occult motions." Objects moved seemingly by themselves, as in the replication of a trick attributed to the mythological inventor Daedalus in which a statue moved "by its own will."[48] Daedalus himself reputedly had used quicksilver to animate a statue of Aphrodite, and while De Sepi did not elaborate on the moving statue found in the Kircherian collection, Kircher's *Magnes* of 1641 revealed that it was actually a statue of Daedalus himself that glided across a stage by means of a magnet hidden beneath the floorboards, a sly and entirely Kircherian attempt at one-upmanship of the ancient craftsman.[49]

The question that remains, however, is how Kircher sought to use his magnetic machines. He designed them explicitly around insensibility and invisibility; their power and utility as spectacles was rooted in the secret and hidden nature of the lodestone and not in the philosophical revelation of magnetic properties and virtues. De Sepi tells us repeatedly that these devices worked by means of an occult power or a hidden force: they were presented not as simple tricks explained by a hidden magnet, but as elaborate demonstrations of a secret, hidden thing. This point is a crucial one, for these machines—collectively, the centerpiece or *medulla* of the Kircherian museum—celebrated rather than exposed the insensible. Kircher used these and other devices in his collection

[48] De Sepi, p. 19.

[49] Athanasius Kircher, *Magnes; sive, De arte magnetica*, 2nd edn (1643), p. 319. On Daedalus's animation of a statue of Aphrodite, see William R. Newman, *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004), pp. 12–13.

not only to demonstrate the occult correspondences that existed in nature, but also to force his visitors to grapple with the problems inherent in trying to study a world "bound by secret knots," as he phrased it on the frontispiece to his 1667 *Regnum naturae magneticum*.

The Kircherian collection was intended to function as more than a repository of objects and machines. Its description as "the epitome of philosophical practice" suggests that Kircher envisioned a practical and philosophical purpose for his museum, and as the avowed centerpiece of the collection these magnetic devices should exemplify that purpose. If we reject the possibility that Kircher buried messages about how to study the world in these machines, however, we are left with a collection of devices that effectively were devoid of intellectual merit. In other words, without an epistemological purpose that commented on the act of knowing, they were philosophically useless. One cannot properly consider them to be natural philosophical instruments because they did not establish or demonstrate anything about the lodestone beyond its ability to move either pieces of iron or other lodestones—that was all these machines did, and surely Kircher did not need or want merely to rehearse this one basic property of the magnet some dozen times or more. Nor can one consider them to be philosophically instructive, for their audiences were patently not instructed in the causes behind the observed effects, which Kircher presented instead as mysterious, hidden, and secret.

Consider, too, the parallels that existed between Kircher's seeming purpose in the display of such devices and the contemporary rhetoric of René Descartes, who claimed in his *Principles* that the use of artifice allowed one to witness and see the operations of nature that were otherwise too small to be witnessed or that were altogether insensible. By reconceptualizing the hidden parts of nature as myriad parts of a vast machine, Descartes and other mechanical philosophers sought to render intelligible what might otherwise remain unknown.[50] It makes sense that Kircher would use the magnetic machines at the heart of his collection to translate the magnet's invisible power into a form of spectacular mechanical motion, creating a means of "seeing" this occult power at work in displays that themselves simulated the wider world. Artifice was ideally suited to this revelation because it imitated nature—it translated natural processes into systems that were observable and controllable. Descartes argued this point explicitly, but I believe we must read the Kircherian collection as articulating this

[50] Brian S. Baigrie, "Descartes's Scientific Illustrations and 'la grande mécanique de la nature,'" in Baigrie, ed., *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science* (Toronto: University of Toronto Press, 1996), pp. 111 and 123.

idea as well; in both cases, the artificial emulation of nature was an instrument of revelation, making insensible processes both visible and comprehensible.

Labyrinths, Fallacies, and Subterfuge

Arguably the single greatest limitation to studying the Kircherian museum is that we are rarely, if ever, enlightened as to the purpose of the machines and puzzles displayed therein. We know what they looked like, how they moved, sometimes even how Kircher constructed them, but we are rarely enlightened beyond this. It is clear, however, that many of these machines were concerned explicitly with questioning the acts of seeing and knowing. For example, as part of his discussion of "Optical, Catoptrical, [and] Dioptrical Experiments," De Sepi described the *theatrum catoptricum*, which addressed the "much-discussed question among Physicists, *of Infinite action*."[51] The principle of the device was simple: Kircher arranged a number of mirrors in such a way that any object placed in the *theatrum* appeared in a seemingly infinite regression of reflected images. The spectator presumably would then use this optical demonstration to contemplate the possibility of actions extended to infinity. This was by no means an idle question: scholastic thinkers had debated the concept of infinity in both theological and mathematical contexts in the medieval period, and clearly the question was, in the middle of the seventeenth century, still "much-discussed."[52]

Upon detailing how, by placing a few miniature trees or shrubs in the *theatrum* one could produce the appearance of an entire orchard (*viridarium*), De Sepi concluded with some satisfaction that "your eye, being deceived by so excellent a labyrinth, thinks itself drawn forth into an infinite space and fields" (*oculus tuus tali labyrintho delusus in infinitum spacium, & campos protractum se putet*). But he also went on to say that, "in physics the probable arguments of contrary opinions supply the daily material of disputation in the schools; here [in the museum] sight seems to establish conclusively by means of convincing appearance that infinity with respect to act is to be granted" (*in Physicis contrariarum sententiarum probabilia argumenta quotidianam in scholis*

[51] De Sepi, p. 36: "*Theatrum Catoptricum*, instrumentum est, quo quæstionem inter Physicos tam celebrem *de Infinito actu*."

[52] As one example of the long history of this question, as well as its theological contexts, see Anne A. Davenport, "The Catholics, the Cathars, and the Concept of Infinity in the Thirteenth Century," *Isis*, vol. 88, no. 2 (June, 1997), pp. 263–95.

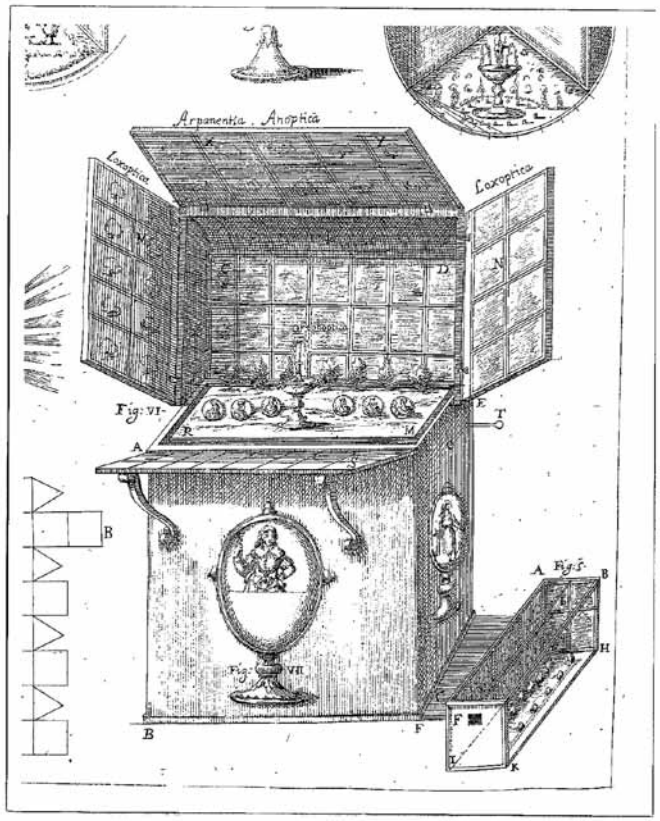

Figure 4.6 The *theatrum catoptricum*, which Kircher used to instruct visitors in the nature of infinity.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

subministrant disputandi materiam; hîc convincente visus apparentiâ conclusivè dari actu infinitum stabilire videtur).[53]

De Sepi's language deserves further attention, but first it is worth noting that this juxtaposition between the disputation of the schools and artificial demonstration draws an important parallel with the culture of "wonderful machines" that existed and thrived around the same time as did Kircher's collection. This culture encompassed a series of practices whereby "public explanation of mathematical problems became a special kind of ritual, a display

[53] De Sepi, pp. 36–7.

of knowledge close in spirit to the 'disputatio' and the public defense of theses,"[54] and was exemplified by the work of a Jesuit mathematician named Paolo Casati (1617–1707) who, in 1655, published his *Terra machinis mota* ("The Earth moved by machines"). Casati was active in the Society of Jesus at precisely the same time that Kircher's museum was becoming one of the intellectual centerpieces of the Collegio Romano, and the *theatrum catoptricum*, with its attention to the question of infinity, would seem to confirm that Kircher himself participated in this culture of public explanation and display.

De Sepi created a clear juxtaposition in his discussion of the *theatrum* between "the schools" on the one hand and the museum on the other, and between the "probable arguments" of the *disputatio* and the "conclusive" evidence provided by sight alone. This was not a simple endorsement of empiricism, however, for De Sepi was careful to note that the *theatrum* only *seems* to establish conclusively the possibility of infinite action, and that it does so with a "convincing appearance" of infinity. This would appear to be a reiteration of the same ambivalence towards the senses that permeated other parts of the Kircherian collection, though De Sepi did suggest that even the optical trickery of the *theatrum* was preferable to the probable wrangling of the *disputatio*. What was important was not that the device in question could or could not create an action that was truly extended to infinity, but that with it Kircher could encourage the contemplation of such an action. Further underscoring the seeming ambivalence towards the senses communicated by De Sepi was the way in which he described how the *theatrum catoptricum* operated on the individual viewer. We know that he emphasized the ease with which the eye could be fooled "by so excellent a labyrinth," but he also considered what effect this would have on the mind. Kircher had designed the *theatrum*, he noted, "so that reason is separated from the senses, or is at least deceived, so that whomever you please might be struck dumb by this instrument" (*ut rationem á sensu separatem, vel saltem deceptam in hoc instrumento quivis obstupescat*). Thus, to be "struck dumb" was to have one's reason separated from one's senses, to disrupt the orderly progression of impressions from the eyes to the mind.

In fact, one could argue that at least one purpose of the spectacular machines in the Kircherian collection was to engage in precisely this disruption of knowing, by driving a wedge between the senses and the mind. Such disruption is, perhaps, implicit in the very production of spectacle, which is meant to amaze and, indeed, to "strike dumb." This may have been comparable to the self-conscious disconnect fostered by early modern skeptics between the fallible

[54] Feldhay, "On Wonderful Machines," p. 153.

senses and the rational mind, though Kircher was certainly not a "skeptic" in the sense embraced by some of his contemporaries.[55] Whatever messages concerning sensual fallibility his museum might have conveyed, it was at the same time an extravagant celebration of those same senses, with its painstaking and opulent attention to the fundamentals of baroque aesthetics. There was no disdain for the senses in the Kircherian collection, and certainly no lack of respect for their power to affect the mind. Ultimately, in its quiet commentary on the act of knowing, the Kircherian museum leavened the extravagance of baroque artistry with instruction that was both more sober and more subtle.

The messages that Kircher encoded in these magnetic and catoptric machines stood in sharp contrast to the basic tenets of Peripatetic psychology and epistemology. Surely, if De Sepi and Kircher adhered even to a nominally Aristotelian way of knowing, we would expect them to uphold the maxim most famously elaborated by Thomas Aquinas: "Nothing exists in the mind that is not first in the senses." And yet, in the *theatrum catoptricum* and the other machines in the Kircherian museum, we find a playful but stubborn refusal to accommodate such an epistemology. Nor should this necessarily surprise us. Strict adherence to Aristotle (and to Aquinas) was an ideal rather than a universal reality in the Society, and any number of Jesuits were willing to adapt, or sidestep altogether, the more inconvenient tenets of their shared philosophy.

Of course, Kircher did not challenge the utility of the senses simply by leading his guests into a dark room, closing the door, and leaving it at that. There were assuredly things to observe and witness throughout the collection: even if one could not see the magnetic force that propelled Typhon across the ocean, one was treated to a lavish and beautiful spectacle of the effects of this propulsion. But if we take seriously Kircher's claims that his museum was a *theatrum mundi*, a reflection of the world, then we—like his baroque audiences—are left to grapple with a worldview in which much is obscured or hidden, revealed only by the playful use of analogy, correspondence, and the careful juxtaposition of Art and Nature.

Beyond the confines of the Kircherian collection, historians have observed that such mirrored cabinets and machines expressed "the Jesuit obsession with resemblance and synthesis, immutability and variation."[56] As an example, the many-mirrored *theatrum polydictium* might be seen as an "analogical device [that] revealed how one entity could become pluralized into a multitudinous creation," much like the *theatrum catoptricum*. At the same time, however, this

[55] See, for example, Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007), esp. ch. 8.

[56] Barbara Maria Stafford and Frances Terpak, *Devices of Wonder: From the World in a Box to Images on a Screen* (Los Angeles: Getty Publications, 2001), p. 26.

highlights how central such machines could be to the Jesuit program of education and edification: "The complexities of visuality inform both Jesuit epistemology and their pedagogy. ... In the hands of the Jesuits ... such devices demonstrated the fickleness of the human mind, the duplicity of sensory appearances, and the convertibility of the physical universe."[57]

An analysis of Kircher's mirrored machines also calls attention to an important spiritual dimension, for "such conjuring devices were also spiritual tools for meditating on the knotty theological problem of divine absence and presence. ... Jesuit catoptric experiments ... can be thought of as mathematical, perspectival, and religious strategies for forcing hidden operations to manifest themselves."[58] We have already seen that Kircher designed at least some of these devices so as to permit the contemplation of such abstracts as the concept of infinity; perhaps, then, we should understand these machines as aids to a kind of secular meditation, permitting a repeated movement between the visible and invisible in the pursuit of understanding. In this, such technologies are again comparable to the magnetic devices discussed above, which encouraged the same movement between seen and unseen.

The mirrored cabinets and catoptric devices of the Kircherian collection, then, were capable of conveying any number of messages to their audiences. Like Kircher's magnetic demonstrations, they were puzzles in need of a solution. But elsewhere in the museum, Kircher displayed machines that were less subtle in the messages they communicated. Consider, for example, a series of devices that appeared to work by means of perpetual motion, that dream of engineers and philosophers dating back to antiquity. In fact, however, these machines were little more than a clever trick designed to expose the ignorant and the unwary. In his catalogue, De Sepi emphasized that these devices displayed merely the appearance of perpetual motion (*De Mobili perpetuo apparente*). After offering his readers a quick refresher in Aristotle's definition of motion as the actualizing of potential and its division into "instantaneous and successive, violent and natural," De Sepi then observed that while in times past "a great many clever devices of philosophers and mathematicians exerted themselves" in the pursuit of perpetual motion, they had been duped by "a vain hope." These past thinkers had constructed such devices only because they did not "understand the principles of nature."[59]

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[57] Stafford and Terpak, p. 27.

[58] Stafford and Terpak, pp. 27, 28.

[59] De Sepi, p. 56: "his praepositis de possibilitate dabilis motus perpetui inquiritur, in quo tot jam saeculis plurima Philosophorum, Mathematicorumque ingenia desudarunt, & dum operam oleumque perdidere vana spe delusi, se naturae principia non intelligere ."

Having dismissed perpetual motion as a fantasy and thereby upholding a fundamental tenet of Aristotelianism, De Sepi then described a number of machines in the Kircherian collection that pretended to demonstrate precisely this kind of motion, first cautioning his readers to remember that these machines "do not profess perpetual motion, but refute it."[60] These devices were based on trickery and subterfuge as were the magnetic and catoptrical machines, but the goal in this case was *not* to be deceived. Their playful intention was to trick the spectator into believing that their motion truly was never-ending, but to believe this was to believe a philosophical fallacy. The magnetic and catoptrical machines illuminated even as they deceived, but these pretenses to perpetual motion did the opposite: to be taken in by the deception was to fail to understand "the principles of nature." Moreover, I suspect that one was made privy to the deception only by the intervention of Kircher himself, thereby echoing the principles at work in the magnetic machines whose mysterious innards and mechanisms were made obvious only by their deliberate revelation.

A Kircherian Epistemology?

Given the myriad ambiguities scattered throughout the Kircherian collection, one cannot help but ask whether Kircher had any interest in creating the kind of demonstrable certainty demanded by Aristotelianism. His museum suggests, instead, that he was committed to promulgating only probable forms of knowledge, and this suggests in turn that Kircher was responding to the changing intellectual currents of his time. Alongside the acquisition of probable knowledge lay powerful messages about sensual fallibility and the inherent weakness of the eyes.[61] This has led modern historians to characterize Kircher's "wonderful works of light and shadow" as an "attempt to unsettle 'the grammar of visibility,'" and indeed a word such as "unsettle" does seem especially appropriate to the Kircherian collection.[62] Much like the notion of separating the senses from the mind, or even the more general ideal of bemusement, it implies that Kircher set out deliberately to undermine the very foundations of knowing, and thereby the epistemological confidence of his audiences.

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[60] De Sepi, p. 56.

[61] Michael John Gorman, "The Angel and the Compass: Athanasius Kircher's Magnetic Geography," in Findlen, ed., *Athanasius Kircher: The Last Man Who Knew Everything*, pp. 255–6.

[62] Clark, *Vanities of the Eye*, p. 101.

Thus, we return to the suggestion that the machines in the museum trained their audiences in "how to see." They accomplished this, in part, by unsettling "the grammar of visibility." In almost every case these devices embodied a critique of the senses, with their emphasis on *seeming* and *appearing* or, conversely, on *hiding* and *obscuring*. Unique as they were to this collection, and forming as they do the core of its catalogue, we can reasonably assume that these machines represented a central expression of a Kircherian epistemology. By creating and exaggerating this "epistemological unreliability" throughout his collection, Kircher was able simultaneously to erode the foundations of one world, as perceived through the lens of a conventional Aristotelian natural philosophy, and replace them with his own vision of the cosmos. The world that Kircher constructed was balanced upon a series of unseen and mysterious foundations, its disparate parts linked by the "secret knots" that Kircher referenced in his works on magnetism. Thus, in its identity as a *theatrum mundi*, the Kircherian collection was fundamentally a theater of the unseen in which the secrets of nature were simultaneously displayed and controlled by Kircher's elaborate, playful machines. Moreover, it was through those machines that Kircher first introduced his visitors to this mysterious new world, and then educated them both in the limits of their understanding and in the tools they might use to push those limits further still.

So uncertain a world may well have been unsettling to baroque audiences, cloaked as it was in metaphorical shadows that resisted conventional observation. Balancing this, however, was Kircher's indefatigable optimism. Where contemporary skeptics despaired of ever knowing nature in its entirety, Kircher remained convinced that understanding was not only possible, but inevitable. His unswerving faith in a providential God made him certain that, no matter how shadowed and hidden the foundations of the world, humanity could and would come to see them, aided by his elaborate machines and his repeated exhortations to see with the eyes of the mind as well as those of the body. Ultimately, Kircher designed his museum so that it might "lead that which is hidden from the most profound shadows into the astonishing light."[63]

[63] Kircher, *Ars magna lucis et umbrae*, p. 834: "Haec autem est divina illa Optice scientia, quae quod abditum est è profundissimis tenebris in admirabile lumen educit."

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Chapter 5
Probabilism, or the World as it Might Be

The Kircherian collection acquainted audiences with uncertainty and exposed the fallibility of their senses even as it displayed a universe that was difficult, perhaps impossible to understand completely. These same principles also shaped a series of important natural philosophical texts written by Kircher over more than twenty years. These works presented their audiences with images and descriptions of phenomena that encouraged a movement between the exercise of the eyes and the exercise of the mind in a fashion that resembles nothing so much as a kind of meditation. Niccolò Cabeo had juxtaposed image and text so as to foster a many-layered understanding of the magnet, doing so within the self-conscious confines of the neo-Aristotelian textbook. Kircher, by contrast, labored under no such confines in his own texts, which were exuberantly syncretic attempts to connect together any number of disparate things: Nature and Art, seen and unseen, known and unknown. While his museum in the Collegio Romano used spectacle and artifice to expose the hidden foundations of nature, in these works Kircher depended upon images and emblems to accomplish the same goal.

This chapter explores three of Kircher's texts: the *Magnes; sive, De arte magnetica* (1641), the *Ars magna lucis et umbrae* (1646), and the *Mundus subterraneus* (1664). Together, they span the better part of his intellectual flourishing, but more importantly, these three texts exemplify Kircher's obsession with unlocking and revealing the secrets of nature. Each was concerned with questions about seeing and, specifically, "how to see"—either how best to apprehend and study insensible phenomena such as the magnetic force or the subterranean realm, or the physics and psychology that supported the acts of seeing and knowing. In each case, Kircher chose subjects broad enough that their examination required multiple approaches; in some cases, he depended upon the authority of the ancients or the unsubstantiated reports of popular belief, while in others he resorted to the rigors of experimentation and the careful testimony of reliable witnesses. Often, he brought most or all of these approaches to bear on individual phenomena. This fluidity of interpretation and methodology can make Kircher's works difficult to decipher. Unlike Cabeo's *Philosophia magnetica*, one cannot classify Kircher's writings as belonging to any

particular camp; they demonstrate a fierce eclecticism that is typical of almost everything he attempted.

These texts were also linked together by their attention to both the perils of uncertainty and the tools Kircher proposed to mitigate or dispel altogether that same uncertainty: elaborate methodologies with which his readers could witness and understand the invisible, connective power of the magnet or the deepest recesses of the Earth. In his museum, these methodologies revolved around the intervention of artifice and its concomitant rhetoric of imitation or similitude. Kircher also repeated this theme in his published works, which he filled with images and descriptions of the very machines on display in his collection, but the way in which he also used pictorial representations transformed these works into texts as grandiose and beautiful as any meditative work commissioned by the Society of Jesus. Indeed, it is as meditative compendia that we should understand Kircher's published works: deliberate and self-conscious attempts to connect the eyes and minds of his audience with both the unseen foundations of the universe and the providential design of its Creator.

In the *Magnes; sive, De arte magnetica* of 1641, Kircher waxed lyrical about the invisible power of the magnet, seeing in the humble lodestone the key to the structure of the cosmos. His text makes for a fascinating counterpoint to the magnetic machines that formed the heart of his collection in Rome: those machines instructed their audiences in how to visualize the insensible correspondences that drove the universe, but the *Magnes* sketched those correspondences in full, using imagery and emblems to do so, becoming finally a grand meditative exercise that sought to connect together the world, humanity, and God. Thereby was the promise of the Kircherian machines realized in full.

Published only five years after the *Magnes*, the *Ars magna lucis et umbrae*, or "The Great Art of Light and Shadow," delved more closely into the particulars of knowing. Easily as ambitious in scope as the *Magnes*, the *Ars magna* addressed both the utility and the deceit of the eye. Therein, Kircher made clear that he would not pursue the empirical certainty demanded by conventional Aristotelianism, and once again he emphasized the importance of artifice in the acquisition of knowledge. As the magnetic machines illustrated in the *Magnes* became instruments of revelation, the science of optics, as reified in the microscope, the telescope, and varied catoptrical devices, became the means simultaneously of bemusing and enlightening the mind.

Arguably one of the greatest of Kircher's later works, the *Mundus subterraneus* or "The Subterranean World" built upon the themes expressed in these earlier texts. It presented the depths of the world as shadowed and mysterious, inaccessible save through the intervention of artifice (which

imitated subterranean processes and thereby exposed them to observation) or the studied contemplation of images (by which Kircher sought to encourage his readers to descend into the Earth and "see" its depths for themselves). It was here that Kircher most explicitly presented his audiences with a probabilistic vision of the world: not as it was, but as it might be.

Together, these works spanned some twenty-five years of Kircher's life, but the general epistemology they presented remained coherent and unified throughout. In every case, Kircher emphasized the utility of artifice in revealing the hidden operations of nature while fostering a self-conscious syncretism that sought to connect together the disparate parts of the world into a coherent, comprehensible whole. At the same time, however, he moved quietly but clearly away from the fundamental tenets of Aristotelianism, openly questioning the pursuit of demonstrative certainty before abandoning it in favor of a more subjective, almost meditative experience in which text, image, and the mind all collaborated in the acquisition of knowledge.

The *Magnes*

Giorgio de Sepi described the magnet as the *medulla* or centerpiece of the Kircherian collection in Rome, and the magnet's invisible power drove some of Kircher's most elaborate and puzzling displays. It is unsurprising, then, that he should have published no less than three separate works devoted to magnetism. The first, his *Ars magnesia*, appeared in 1631 and is generally considered to be Kircher's first published work. The *Regnum naturae magneticum* appeared in 1667, proclaiming on its frontispiece, *Arcanis nodis ligatur mundus*—"The world is bound by secret knots," perhaps one of Kircher's best-known maxims. But it is his middle work on the magnet, the *Magnes; sive, De arte magnetica*, that will occupy our attention here. It was Kircher's greatest work on the subject, appearing first in 1641 and going through two subsequent editions in 1643 and 1654.

Kircher cast the magnet as the greatest exemplar of nature's hidden secrets in his museum, and he echoed this throughout the pages of the *Magnes*. With a nod to the dramatic, he opened this work with numerous allusions to shadows and darkness.[1] Characterizing his own quest for a means of describing and demonstrating the activity of the magnet in such terms not only permitted Kircher to underscore its difficulty and the general state of ignorance that

[1] Athanasius Kircher, S.J., *Magnes; sive, De arte magnetica opus tripartitum*, 2nd edn (Cologne, 1643), *Prooemium ad Lectorem*, p. 2.

prevailed concerning this most pre-eminent of nature's mysteries, but also forged a link with Cabeo's earlier rhetoric in the *Philosophia magnetica*, in which the Italian Jesuit had characterized his own work as an illumination of shadows. In fact, there are numerous parallels between Kircher's *Magnes* and Cabeo's *Philosophia*, and Kircher was quick to praise Cabeo as one of "those others who are not without glory in this Herculean labor" and who had corrected the errors found in the work of "the Englishman Gilbert."[2]

From the start, then, Kircher encouraged his audience to view the work that followed as a kind of revelation, a lifting of shadows. From this grandiose beginning, however, his prose fell into a rather dry recitation of the magnetic nature, a description of various aspects and "faculties" of the magnet itself—for example, that its force extends outwards in a sphere, that it propagates its force in straight lines, and that its natural motion is circular, all claims made previously by Cabeo. Kircher also echoed Cabeo in his assertion that the Earth's magnetic attraction to the celestial poles made it incapable of motion, explaining that God had providentially designed it thus so as to balance and preserve both climate and life on the terrestrial surface: were either the Earth or poles to "fluctuate" or change, chaos would result, and those animals and plants created to thrive in one climate would suffer in another.[3]

The first section of the *Magnes*, introductory in nature, not only established the basic nature of the magnet but also linked the magnet with other natural phenomena, particularly light. It was precisely the kind of description that Cabeo had advanced in 1629, and thus bears the hallmarks of Peripatetic arguments concerned with the propagation of species or qualities. Kircher pointed out that both the magnet and light diffused their respective qualities through a passive medium, and that in doing so they would not be altered "too much" by the medium itself but would themselves induce a "certain and determined alteration" in a receptive body.[4] Moreover, while the propagation of light could be stopped by "neither cold, nor heat, nor glassy bodies, nor water, nor the hardest crystal"—only opacity was "inimical" to light, preventing its further

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[2] Kircher, *Magnes* (1643), *Prooemium ad Lectorem*, p. 3: "quos inter Gilbertus Anglus, vel tanto reliquis eminentior censeri debet, quanto de Magnetis natura primus, verius, subtiliusque philosophatus est; tum Leonardo Garzonius, quorum vestigiis insistens, singularis ingenii atque industriae Vir Nicolaus Cabeus e Societate nostra Sacerdos, de suo penu selectas quasdam rarioresque observationes producens, rationesque experimentis probatissimis coniungens, quae in Gilberto aliisque circa Magnetis naturam fallaciae errorisque occasionem praebere poterant, detexit. "

[3] Kircher, *Magnes* (1643), p. 40.

[4] Kircher, *Magnes* (1643), p. 59.

propagation—the magnet's propagation of quality was more powerful still, unaffected by the interposition of objects that were "heated, or cooled, or dense, or rare, or opaque, or translucent," leading Kircher to suggest that the magnet could diffuse a quality out from itself with a force that was almost spiritual in nature—"spiritual," that is, in the sense that material obstacles could not impede this propagation of quality.[5]

There is little in the first book of the *Magnes* that can be considered original to Kircher. At the same time, however, it is by far the shortest of the three books that together comprise the *Magnes*, a fact that speaks eloquently to the priorities that guided Kircher in the production of this text. This basic explanation of the magnetic nature, certainly the most blatantly "natural philosophical" material in the *Magnes* and the only content that one might deem properly Peripatetic, was of relatively little importance in the larger scheme of the work that Kircher envisioned. This suggests that the questions he sought to answer were primarily not those we might expect of a "proper" experimentalist, nor of a Peripatetic naturalist. This may explain why many, including biographers of Kircher, have struggled to characterize his work as something more than a collection of oddities, but it also points us towards the true subject of Kircher's *Magnes*. It was a two-fold endeavor: firstly, the consideration of an invisible and pervasive unity that was portrayed emblematically by the magnet, and secondly, an outline of the methodological and epistemological means of examining and comprehending that unity. As in his museum, Kircher used the *Magnes* to celebrate the insensible, but he also provided his readers with clues as to how to study it.

The next section of the *Magnes* was not a dry recitation of philosophical facts but an exuberant and, at times, implausible disquisition on applied magnetism. This second book of the *Magnes* was entitled, "On the magnetic art, or the magnet applied," and an early modern thinker might have considered it an extended rumination on the possibilities of natural and artificial magic—that is, the manipulation of unseen forces in the production of specific effects.

[5] Kircher, *Magnes* (1643), p. 73: "*Comprario lucis cum Magnete*"—"Non secus ac corpus luminosum, quod qualitatem suam uniformiter difformiter uno momento ita propagat per medium, ut non frigus, non calor, non vitrea corpora, non aqua, non crystallus durissima impedire possint, quo minus eo in medio vim suam exerat; sola opacitas inimica lucis ipsi qualitati circumfusae frena injicit … . Hac itaque ratione Magnes producit qualitatem suam in circumiectis corporibus, sive ea calida fuerint, sive frigida, siva densa, sive rara, sive opaca, sive translucida, sive etiam quamlibet aliam habeant e contrarijs qualitatibus; & hoc, quia istae qualitates nullam habent omnino contrarietatem nec directam, nec indirectam cum Magnetica qualitate producenda, ergo actionem eius impedire quoque nulla ratione possunt: accedit quod illa qualitas omnis quantitatis corporeae expers, ceu spirituale quippiam vim suam diffundat."

Indeed, Kircher used the term "natural magic" to describe some of the elaborate magnetic machines he envisioned—the heading of one section was "*Magia Naturalis Magnetica*"—and so it is unsurprising that it was here that the first depictions of Kircher's wondrous magnetic machines appeared, some of which also took center-stage in his early collection. Thus, he first articulated in 1641 many of the messages later embodied in his museum, as Kircher ruminated on the possibilities presented by the artificial demonstration of the magnetic force. The engraved illustrations that fill this part of the *Magnes* evince a richness and detail that stand in sharp contrast to the much simpler woodcut renderings included in the first book, another clue to the priorities at work in this text. That Kircher went to the effort and expense of commissioning so many detailed illustrations, many of them technical in nature and thus requiring still greater levels of attention in their production, suggests that Kircher saw these particular illustrations as critically important in the overall scheme of his *Magnes*. Indeed, devoted as this work was to the construction of a magnetic art, one could argue that these technical and practical illustrations did form a crucial focus for Kircher's endeavor.

Most of the copper engravings in the *Magnes* depicted instruments that were designed to exploit the pervasive and invisible power of the magnet, though two such illustrations employed moving parts that the interested reader could cut out and then assemble to create actual instruments within the text itself.[6] Other illustrations depicted merely the face of a theoretical device or magnetically-driven machine, demonstrating the portion of the instrument that would be used, for example, to calculate time or map the movement of the heavens.[7] Some engravings also purported to demonstrate the actual mechanism required to construct particular machines such as a magnetic clock, complete with a cutaway view of the clock's base and the gears within. These illustrations were practical in nature, functioning both as instruments in and of themselves and as guides to the ingenious reader who desired to comprehend or even construct these wondrous magnetic machines.

Another such illustration highlighted the utilitarian and spectacular (as opposed to philosophical) emphasis that lay behind Kircher's interest in the magnet. We might recall that De Sepi mentioned a statue that moved "by its own will" in the Kircherian collection, and which the *Magnes* revealed to be

[6] In Kircher, *Magnes* (1643), these moving instruments appear on pp. 254 ("Kalendarium magneticum") and 364 respectively.

[7] For example, the engraving of the "Horoscopium Universale" in Kircher, *Magnes* (1643), p. 276 depicts the calculating apparatus that would appear on the face of a machine that one could use to follow and chart the motion of the heavens.

Daedalus.[8] In discussing this self-moving statue, Kircher included an illustration that depicted Daedalus frozen in the act of moving, standing in the centre of a stage framed by a vast archway and a solid backdrop, both covered with dozens of mirrors. The text that accompanied this illustration described the purpose of this particular demonstration: "*Catoptrica Magnetica;* in which, by a certain disposition of mirrors, reflected and multiplied images exhibit diverse and joyous spectacles of things by means of magnetic motion."[9] Note the use of the term "spectacles"—the moving statue, like the rest of the wondrous magnetic devices and machines that Kircher described, presented in its own activity a spectacle of the magnetic force, a means of seeing or witnessing that force at work. Note, too, what Kircher proposed to exhibit with his multitude of mirrors: not the hidden mysteries of the magnet, but the veracity of the magnet's mysterious efficacy. In other words, what Kircher displayed was not the occult causes of magnetism but an altogether different thing: the wondrous nature and uses of the magnetic force. This was also what the magnetic machines on display in the Kircherian collection offered to their audiences: they did not necessarily enlighten their audiences as to the philosophical causes behind the spectacles they presented but, rather, highlighted the mysterious and pervasive power of the insensible correspondences that webbed the cosmos.

While the second book of the *Magnes* detailed the application of magnetism to the production of particular effects and displayed in the workings of these machines the unseen correspondences that pervaded the universe, the third and final book examined these correspondences themselves. It was here that Kircher explored his emblematic worldview, its basic principles made clear in the title, "The magnetic world, or magnetic chains." This notion of chains was to become a central and symbolic expression, and Kircher promised in the opening pages of the third book to discuss "the magnetic binding of all natural things."[10] This third book of the *Magnes* is the longest by far, suggesting that it was here, in this discussion of "the binding of all natural things," that Kircher focused most of his attention.

The magnet, with its ability to influence distant objects by means of a hidden power or force, operated for Kircher as a reification of the invisible bindings between natural objects. His worldview consequently depended upon the occult to a significant degree, for the invisible and intangible nature

[8] Giorgio De Sepi, *Romani Collegii Societatis Jesu Musaeum Celeberrimum* (Amsterdam: Ex Officina Janssonio-Waesbergiana, 1678), p. 19.

[9] Kircher, *Magnes* (1643), p. 319: "Catoptrica Magnetica; Qua certa speculorum dispositione imagines reflexae; & multiplicatae motu Magnetico varia iucundaque rerum exhibent spectacula."

[10] Kircher, *Magnes* (1643), p. 463.

of these correspondences confirmed for him their divine provenance. At the same time, however, the *Magnes* demonstrated an obvious desire on Kircher's part to render manifest the unseen, a feat that he accomplished in two distinct but related ways. The first, which was spectacle, we have already encountered: the myriad machines and devices illustrated and described in the *Magnes* (and made real in the Kircherian museum) demonstrated the wondrous uses and effects of magnetism, making these things tangible to their audience. The second way in which Kircher rendered manifest and tangible the unseen links between things, however, lay in the realm of emblematics, which portrayed in visual form the unseen magnetic correspondences between natural objects as chains and knots.

Though the magnet was the ostensible subject of Kircher's work in the *Magnes*, in the third and final book he quickly moved beyond the magnet itself when he started to discuss a wider system of linkages between natural things. To his own question, "What is the key of nature?" Kircher responded, "There is one key to nature, a singular thing, that sets forth unity in dissimilar materials."[11] This "singular thing" was a form of magnetism, though one that operated between any number of objects rather than merely between the lodestone and iron, and its ability to create unity from disparity occupied a position of crucial importance in Kircher's worldview. His notion of a pervasive system of linkages between things also dovetailed with his claim that "consensus and dissension" were the two primary forces that drove the universe, possibly an homage to the classical Empedoclean forces of Love and Strife.[12] Examples included the movements of the planets (about which he disagreed with Johannes Kepler, who had invoked a kind of magnetism to explain his heliocentric cosmological system[13]) and meteorological phenomena, as well as the magnetic links between the elements that permitted the ingenious wonder-worker to change one into the other using a series of machines—for example, turning water into air, or air into fire.[14] Kircher also addressed a number of interesting questions such as "whether light is drawn magnetically" to the Bolognian Stone, one of the only phosphorescent substances then

[11] Kircher (1643), p. 469.

[12] Kircher, *Magnes* (1643), p. 463. See F. Solmsen, "Love and Strife in Empedocles' Cosmology," *Phronesis*, vol. 10, no. 2 (1965), pp. 109–48.

[13] Kircher, *Magnes* (1643), pp. 486–99: "Argumentorum Kepleri confutatio."

[14] Kircher, *Magnes* (1643), pp. 520–60.

known,[15] and argued that the tides were the result of complex magnetic forces acting between the sun, the moon, and the oceans.[16]

As he proceeded through this final section of the *Magnes*, Kircher ascended to ever-greater heights of rhetorical showmanship, culminating in a long disquisition on the metaphysical dimensions of magnetism. Having exhausted his store of physical phenomena, he turned to the subject of love, the ultimate consensus between subjects that brought the disparate into harmony, devoting a lengthy section to "the wonderful power and energy of love."[17] Kircher insisted not only that love was present in all things, but that it was also "the author and conservator of all things" and that "all arts and sciences are produced from love."[18] Attaching these claims to a comprehensive and informative list of the "symptoms of love,"[19] Kircher drew a conflation between love and magnetism: both existed within all things, and both seemed to drive the forces of "consensus and dissension" so central to Kircher's worldview.

Immediately following this discussion of love, audiences reached the end of the *Magnes* and a final epilogue: "*Magnes Epilogus, id est, Deus Opt. Max.*" Kircher announced here that "there is a force connecting all things, which is the Holy Spirit,"[20] and went on to discuss the chains that bind our minds to God as well as to the world.[21] In many respects, this is the most important part of the *Magnes*, the culmination of everything that has come before: the final word and, indeed, the final goal of Kircher's treatise, demonstrating that we are linked to God. These links, present in the natural world yet also joining us to God, mind to mind, soul to spirit, were, for Kircher, the ultimate justification for why the magnet deserved scrutiny. Magnetism, consensus, love, the Holy Spirit—however he chose to characterize this binding force, Kircher made it clear that they were all one and the same thing, a power that was everywhere

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15 Kircher, *Magnes* (1643), p. 581: "De Lapide Phosphoro, sive Luminari, quis sit? & an Magnetice lumen trahat?" For more on seventeenth-century ideas about this phenomenon, see E. Newton Harvey, *A History of Luminescence: From the Earliest Times Until 1900* (Philadelphia: American Philosophical Society, 1957).

16 Kircher, *Magnes* (1643), p. 586.

17 Kircher, *Magnes* (1643), p. 777: "De mirabili vi & energia Amoris."

18 Kircher, *Magnes* (1643), pp. 779–81.

19 Kircher, *Magnes* (1643), p. 779: "Vide obsecro illorum assiduos gemitus, querelas, minas, preces incompositas, insomma, lachrymarum fontes assiduos, vanam formidinem, atque ridiculam spem, itam, zelotypiam, nunc ridentes, nunc flentes, iam abblandientes, modo indignatione effervescentes, modo rubore, nunc pallore, gaudio tristitiaque colluctantibus, suffusos' "

20 Kircher, *Magnes* (1643), p. 791: " vis connectens omnia, quae est Spiritus Sanctus."

21 Kircher, *Magnes* (1643), pp. 795–6.

and linked everything. We may witness it most directly, most easily, in the simple object that is the magnet, but the power that draws a piece of iron to a lodestone is no different in kind from the forces that govern the universe and everything in it.

The epilogue of the *Magnes* casts the rest of the work in a spiritual light, a key point if we are to understand the connections between Kircher's emblematic worldview, his insistence on rendering these chains visible and knowable, and the wider mission of the Society of Jesus, which was founded on a commitment to finding God in all things. With this epilogue, Kircher turned the *Magnes* itself into a kind of spiritual journey, from the dry and brief discussion of the magnet's properties at the beginning to this mystical and theological apex at the very end. The journey between these points included a series of successive revelations, first of the properties of the magnet's power, then of the myriad uses of that power, and then of the place of that power in the wider system of the world. Indeed, those who read this epilogue were experiencing another kind of revelation, spiritual in nature. In an important sense, this epilogue shows us that Kircher sought to use his *Magnes* to train his readers in the same kind of contemplative exercise that was central to the formation of the early modern Jesuit; through observation, imagination, and contemplation of the humble lodestone we are meant to apprehend not just God, but also His ties to the natural world. There is a theological project here as well as a philosophical one.

In its entirety, the *Magnes* provided readers with a vision of the insensible parts of the world—or, more particularly, a vision of the insensible links that webbed the cosmos. The entire text functioned as a sort of map, laying out where one might find these correspondences and how one might best "see" them in action. One finds in the *Magnes* a work that was highly ordered, leading its readers carefully (if, perhaps, ponderously) towards an understanding of universal unity and the respective places within this web of correspondences of natural objects like the magnet, the inquiring mind of the naturalist, and the ever-present hand of God.

Secret Knots and Chains

Kircher not only alluded rhetorically in his *Magnes* to the invisible correspondences that pervaded the universe, but also displayed them visually as well in the form of elaborate emblematics. Emblematic representations are usually built upon a framework of links and correspondences where one thing

symbolizes or represents something else entirely.[22] In the *Magnes*, emblematics were not intended to represent faithfully or literally any particular properties of the magnet, but instead to depict the place of the magnet within the wider universe. Kircher's willingness to use this model of representation was rooted in how this model had already been used within the Society: namely, as a means of both representation and dissemination. Alongside the images found in much of the formative meditative literature circulating within the Society was a complementary tradition that favored the use of the classically-inspired emblem as a representational tool, reaching its zenith with the publication of the *Imago primi saeculi Societatis Jesu* of 1640. The importance of emblematics to Jesuit pedagogy and publicity was also closely tied up with notions of spectacle: the lavish plays and performances staged in Jesuit colleges drew heavily upon emblematic associations.[23] Thus, the fact that Kircher drew on an emblematic worldview in his efforts to showcase the powers of the magnet is unsurprising. His commitment to this form of symbolic hermeneutics recalled both the earlier writings of Renaissance naturalists and the thriving emblematic tradition that reached its height within the Society in the decades prior to the publication of Kircher's work on the magnet.

As Cabeo had earlier gone about attempting to make visible the occult force of the magnet through a series of visual and rhetorical tools, so too did Kircher choose to represent the invisible visually in a grand emblematic frontispiece that appeared in his *Magnes*. Before the third edition, however, this emblematic image was only the frontispiece to the third and final book of the treatise.[24] Until then, the frontispiece of the 1641 and 1643 editions functioned more as an explicit dedication to Ferdinand III and the Hapsburg monarchy, with the double-headed Hapsburg eagle surmounted by the imperial crown and clutching in its claws three lesser crowns and three scepters, all linked magnetically, one to the other. The motto that curled around the legs of the eagle read, "Et Boreae et Austri Acus," a play on words that linked the compass, "the needle of both north

[22] William B. Ashworth, Jr., "Natural History and the Emblematic World View," in David C. Lindberg and Robert S. Westman, eds., *Reappraisals of the Scientific Revolution* (Cambridge: Cambridge University Press, 1990), pp. 303–32; James J. Bono, *The Word of God and the Languages of Man: Interpreting Nature in Early Modern Science and Medicine (Volume I: Ficino to Descartes)* (Madison: University of Wisconsin Press, 1995), ch. 6.

[23] G. Richard Dimler, S.J., "Humanism and the Rise of the Jesuit Emblem," in *Emblematic Perceptions: Essays in Honor of William S. Heckscher*, ed. Peter M. Daly (Baden-Baden: Verlag Valentin Koerner, 1997), pp. 98–101 in particular.

[24] The original frontispiece for Kircher, *Magnes* (1641), Book III states, *Liber tertius*, or "the third book"; in the 1654 edition, this has been changed to *Libri tres*, "three books," referring to the whole of the *Magnes*.

Figure 5.1 The Hapsburg-themed frontispiece of the *Magnes; sive, De arte magnetica*, 2nd ed. (1643).

Source: Courtesy Department of Special Collections, Stanford University Libraries.

and south," with the house of Austria, "Austri-acus." When the frontispiece to the final volume of the *Magnes* became the frontispiece for the entire work in 1654, however, the dedication to Ferdinand IV all but disappeared, lost amidst the profusion of images. A new, central motto now overshadowed the Hapsburg dynasty, both figuratively and literally: *Omnia nodis arcanis connexa quiescunt*, "All things rest connected by secret knots." Though we cannot know for certain whether Kircher himself chose to employ this particular representation as the frontispiece of the entire *Magnes* by its third edition, this emblematic scene expresses more faithfully the conceptual foundations of the *Magnes* than did the previous paean to the Hapsburgs.

The new frontispiece to the *Magnes* portrayed a vast schema in which "magnetic chains" not only bind together the entirety of human art and learning but also link the microcosm of humanity, the sublunary world, and the celestial realm with the "archetypal world," the world of God as Creator. This theme of connections and linkages is repeated throughout; in the background, we move from the roots of trees burrowing into the ground to the cloudy heavens overhead, these two realms of the terrestrial and celestial linked by the complex arrangement of chains and discs that overlays this natural backdrop. Fourteen human arts are represented and named, with theology pre-eminent at the very top of the schema, flanked by philosophy and medicine, and followed then by natural magic, arithmetic, geography, music, astronomy, optics, mechanics, cosmography, rhetoric, poetry, and physics. Each of these is linked in turn to the central discs symbolizing the three main divisions of the cosmos—sublunary or terrestrial, superlunary or celestial, and the human microcosm—which surround, but are not actually linked to, the *mundus archetypus*, the archetypal world symbolized here by the radiant eye of God situated in the center of two triangles. What Kircher produced in this emblematic schema was a figurative map of the *Magnes* itself: the links between the arts and sciences exemplified in the investigation and utilization of magnetism, and the application of these arts and sciences to the subsequent investigation of the correspondences between the macrocosm, the microcosm, and the divine.

Kircher chose to represent the invisible magnetic force emblematically as chains, a theme that he repeated both in the frontispiece to the earlier editions of the *Magnes* and in the frontispiece to the later *Regnum naturae magneticum*, which appeared in 1667. In every case, these chains exemplified the links that Kircher believed to pervade the cosmos. Their ability to bind one thing to another was emblematic not only of the activity of the magnet itself, but also of the wider correspondences that one could follow from natural things directly to God. This account was one level on which Kircher displayed the power and

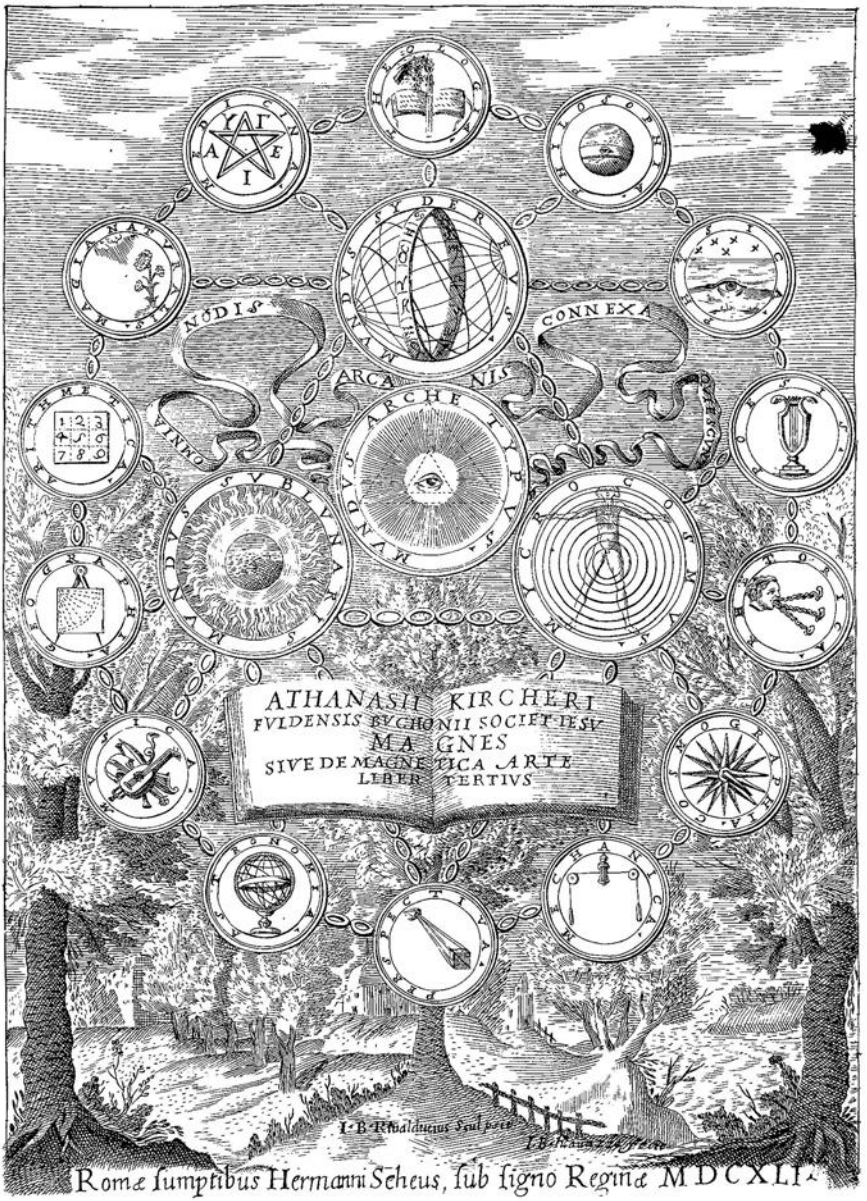

Figure 5.2 "All things rest connected by secret knots": an emblematic schema representing the connective power of Kircher's unseen correspondences.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

activity of the magnet, using a symbolic hermeneutics to clarify for the reader the role of the magnet in the wider cosmos.

That Kircher not only employed actual printed emblematics in his attempts to represent magnetism, but also constructed an entire emblematic worldview centered on the magnet itself, allowed him to portray and exhibit the magnet's occult force without diminishing its value as an example of invisible correspondences in the natural world. This approach was not the same as Cabeo's insistence on exposing and illuminating the secrets of the magnet. Kircher appealed to different visual strategies: on the one hand, concrete representations designed to demonstrate only the effects of magnetism, and on the other, an emblematic representation that privileged the hidden nature of the magnet itself by portraying magnetism in an abstract, symbolic fashion.

Thus, what was important for Kircher was not the precise rendering of these magnetic chains, but rather their manifestation in a fashion that would permit the viewer to comprehend (and marvel at) the unity binding together all of Creation. From Kircher's use of emblematics, both as a model for the ties between disparate objects and as a means of representing visually his scheme for a world linked by secret knots, to his subtle and skillful use of spectacle as an effective means of making apparent to his audience the presence and power of these correspondences, we are confronted in the *Magnes* with an attempt to draw back the curtain and expose to view a system of linkages or, more precisely, a universal unity that, though shaped and mediated by invisible chains, could be revealed and demonstrated. This was Kircher's attempt to capture, as best he could, the harmony and unity of Creation and present to his audience a series of images, emblems, and spectacles that converted the invisible to the visible while simultaneously serving as a kind of religious devotion, confirming God's presence at the center of this harmony and unity, and encouraging readers to revere that presence.

Kircher preserved the magnet as a symbol of the occult in nature, allowing this exemplar of the invisible to express in visible and manifest terms the correspondences that Kircher himself perceived between all things. Cabeo, by contrast, had turned to a series of iconic and illustrative representations in his efforts to open the magnet's hidden properties to view; for Cabeo, the issue at stake was the revelation of a hidden thing. Indeed, these differences between the respective programs of Cabeo and Kircher are obvious even in the titles of the works in question. Cabeo produced a work devoted to a magnetic *philosophy*, an endeavor that required the exposure of the magnet's innermost principles through Peripatetic reasoning and the establishment of the magnet's intelligibility as a natural object. His rhetoric of seeing and vision was both tied

to the empirical foundations of Aristotelianism and encouraged by the "figures and pictures" added to enhance the text, suggesting that the usefulness of those images lay not necessarily in the knowledge they directly conveyed but rather in their mediation between seeing with the eyes and understanding with the rational mind. His diagrams and demonstrations were fundamentally illustrative and iconic in nature, and so did not need to be technical or precise.

Kircher, on the other hand, produced a treatise on the magnetic *art*, an enterprise fundamentally different from Cabeo's philosophical work. For Kircher, the importance of the magnet lay in the potential uses of its properties and in its reification of the unseen correspondences that webbed the universe. Whereas the "figures and pictures" produced by Cabeo functioned as devices of revelation that simultaneously represented an aspect of the magnet's hidden power and exercised the eyes in the service of philosophical understanding, the highly detailed and technical diagrams included in Kircher's *Magnes* functioned instead as a guide for the practical philosopher, as blueprints for the manufacture of machines, and as illustrations of the varied applications of the magnetic art. The majority of his diagrams and demonstrations were illustrative, but also encouraged the reader to witness and experience the power of magnetism for himself.

The *Ars magna lucis et umbrae*

In a letter to John Pell in 1646, Margaret Cavendish (1623–1673) remarked of Kircher's most recent work, "I saw lately a book of the Jesuit Kircher, on light and shadow; it has so many fine figures in it, that I suspect it has no great matter in it."[25] Her disdain, however, was misplaced; Kircher's *Ars magna lucis et umbrae*, or "The Great Art of Light and Shadow," was a far more ambitious work than the *Magnes*. Published in 1646, its scope was vast: Kircher himself declared in its opening pages that its domain encompassed the entire universe, for everything possessed combinations of Light and Shadow.[26] Its central preoccupation with these two things permitted the *Ars magna* to become a powerful commentary on both seeing and knowing. Buried within its nearly one thousand pages are indications that Kircher fashioned an epistemology that veered away from Peripateticism in its attempts to accommodate the mingled

[25] C. Chevalley, "L'*Ars magna lucis et umbrae* d'Athanase Kircher: Néoplatonisme, hermétisme et 'nouvelle philosophie,'" *Baroque*, 12 (1987), p. 98.

[26] Athanasius Kircher, S.J., *Ars magna lucis et umbrae* (Rome, 1646), *Praefatio*, p. ii.

necessity and fallibility of the senses. The *Ars magna* was in fact an extended disquisition on the fundamentals of knowing: not merely the action of the eye, but its deception as well. This text, perhaps more than any other that Kircher produced, sought to explore and expose the fundamentals of knowing. Its contents ranged from sardonic disquisitions on Peripatetic logic to praise for the utility of spectacle, from celebrations of the senses to sober reflections on how little of the world we actually perceive.

At first glance, the quest for coherence in the *Ars magna* is daunting, despite what some have argued.[27] There was something in Kircher's text for everyone: for botanists, there were descriptions of the effect of light on plants, including, of course, the heliotrope or sunflower, whose movement Kircher had discussed in his *Magnes* as an example of sympathetic correspondences but which he explained here as a mechanical reaction to the heat of the sun; for zoologists and anatomists, there were discussions about the structure of the eye and of phosphorescent animals; and for astronomers and astrologers, there were extended ruminations on the motions of the heavens and their effects on the terrestrial realm.

The reader of the *Ars magna* is constantly shuffled between image and text, text and image; as a result, the work is "neither an illustrated text nor a book of images" and thus requires a "double reading" which some, at least, have found disconcerting.[28] We might extend this observation to both the *Magnes* and the later *Mundus subterraneus* as well, for they too exemplify this constant movement between image and text. The idea that this "double reading" should be disconcerting recalls, too, claims that Kircher sought to "unsettle the grammar of visibility," not merely in an epistemological sense as witnessed in the previous chapter but as embodied in the structure of his books as well.

The *Ars magna* was bewildering in other ways as well: it overflowed with axioms, theorems, definitions, and hypotheses, containing "84 definitions divided into 6 groups, 25 axioms in 3 groups, 10 pure hypotheses, 13 hypotheses 'or pronouncements' and 13 other hypotheses 'or postulates.'" This was in addition to the *Propositiones*, *Theorumena*, *Theorema*, *Petitiones*, *Consectaria*, *Canones*, *Problemata*, *Regulae*, *Pragmatia*, *Corollaria*, *Prolusiones*, *Experimenta*, *Machinamenta*, *Parastasis*, *Distinctiones*, *Technasma*, *Fabrica*, *Usus*, *Metamorphoses*, and *Epicherema* with which Kircher sought to establish his claims. In effect, these numerous axioms became a sort of *trompe l'oeil*, a repeated rhetorical illusion: while appearing to create an elaborate philosophical

[27] Chevalley, p. 95.
[28] Chevalley, p. 99.

edifice that confirmed Kircher's claims, they were often accompanied by little more than the hoary propositions of ancient and medieval authorities.[29]

This rhetorical illusion, in which Kircher dressed up traditional sources of authority in the guise of a sophisticated but empty technical vocabulary, may have allowed him to conform, at least ostensibly, with the philosophical and pedagogical foundations of his order while simultaneously reaching towards the vocabulary and methodology of a new, emerging "science." This is bolstered by the fact that Jesuit educators in this period still taught and commented upon the same authorities from whom Kircher borrowed his own claims, even as proponents of the "new philosophies" turned away from these authorities in ever-increasing numbers. Whether Kircher deliberately engineered this textual *trompe l'oeil* or it was instead merely a reflection of his idiosyncratic approach to knowledge, however, it illustrates a larger truth about the *Ars magna*: it was a text that occupied rhetorical and intellectual spaces somewhere in between different approaches to natural philosophy. Kircher did not shy away from the ideas and arguments advanced by the "new philosophies"; indeed, in the first pages of the *Ars magna* he described the observations of the sun made by both Galileo and Kircher's Jesuit contemporary Christoph Scheiner, and included Kepler among the "many modern philosophers" who had claimed that the sun was a solid body. Kircher's judicious and cogent discussion of these modern ideas, however, alternated with references to Aristotle and Albertus Magnus, creating an elaborate synthesis in which all authorities, modern or otherwise, appeared to support one another.

If Kircher relied occasionally on the testimony of traditional authorities, however, he certainly did not always do so in service to the Peripatetic philosophy. In fact, there are several points in the *Ars magna* where he articulated what appears to be a sly refutation of the Peripateticism upheld by his own order. Chevalley claims that Kircher's attitude towards this philosophy took the form of "two distinct tactics: that of frontal attack, and that of irony." The frontal attacks were numerous but carefully hidden, and Kircher used them to denounce "the abstraction of the scholastic philosophy, its fear of reality, its refuge in speculation."[30] It is more difficult, of course, to read for irony in a printed text, especially one published centuries ago. There are indications, however, that Kircher sought to present the principles of Peripateticism in a distinctly ironic tone; for example, in the midst of describing various examples of glowing animals and minerals, he suddenly presented a "scholastic disquisition

[29] Chevalley, p. 99.
[30] Chevalley, p. 102.

on the nature and influence of light in the sublunary world, and its causalities" (*De natura, & efficientia Luminis in mundo sublunari, eiusque causalitatibus, scholastica disquisitio*).[31] What followed was a ponderous exercise in Peripatetic logic, in which Kircher described illumination (*lumen*) with reference to each of the four Aristotelian causes: final, material, efficient, and formal. After devoting a lengthy paragraph to each, he concluded with the following:

> Light therefore is known to be nothing other than a sensible quality produced by a shining body and present in a transparent [*perspicuo*] body, to which it assists in the engendering of heat, the detection of colors, and the sense representation of shining things, and by which it can be conserved for a long time in a transparent [*diaphano*] thing. And indeed this definition touches upon all the causes of light: formal, provided that it articulates a sensible quality; material, provided that it places itself in transparent bodies; efficient, provided that a real efficient power is to be preserved by a shining body; and final, provided that it articulates the production of heat, and the detection of colors.[32]

Just two pages previously, Kircher had considered Peripatetic arguments that sought to establish light as an accident:

> That which is present or absent, without being subject to corruption, is an accident: light is present in the air and in a transparent thing without the corruption of the same; therefore illumination [*lumen*] is an image [*imago*] of light [*lucis*], and the visible species of a glowing thing [*rei lucidae*]; but an image representing an object in the cognitive faculties [of the mind] is not a substance, but an accident: therefore [light is an accident].[33]

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[31] Kircher, *Ars magna lucis et umbrae*, p. 31.

[32] Kircher, *Ars magna lucis et umbrae*, p. 34: "Patet igitur lumen nihil aliud esse, nisi sensibilem qualitatem physicè productam a corpore lucido praesente in corpore perspicuo, cui assistit procreativa caloris, detectiva colorum, & repraesentativa sensui lucidorum, a quibus diu conservari potest in diaphano. Quae quidem definitio causas omnes luminis attingit; formalem, dum eam dicit qualitatem sensibilem; materialem, dum corpori diaphano id assistere; effictricem, dum eam reali efficientia a corpore lucido conservari; finalem denique, dum productivum caloris, detectivum coloris dicit."

[33] Kircher, *Ars magna lucis et umbrae*, p. 32: "Quod adest, vel abest sine subiecti corruptione, est accidens; lumen aeri, perspicuoque adest sine eiusdem corruptione: ergo lumen est imago lucis, speciesque visibilis rei lucidae; at imago facultati cognitrici repraesentans objectum non est substantia, sed accidens: ergo."

There is a sense of the absurd about these passages, an impression that Kircher was casting sly aspersions on this kind of Peripatetic reasoning. It was the sort of exercise that the early modern philosophical reformers despised, arguing a great many things but ultimately saying nothing—after all, what possible use could there be in affirming that light was an accident rather than a substance in its own right? Kircher seems to encourage us to laugh along with him, to shake our heads at such reasoning, the absurdity of which was made all the more clear by the fact that these "scholastic disquisitions" were presented as a clear *non sequitur*, a jarring disconnect from the surrounding pages and their more engaging descriptions of glowing minerals and other wondrous phenomena (to which Kircher returned promptly).

An attentive reader might have understood that these explanations did not reflect how Kircher himself understood light. These were not formal disquisitions on the nature of light undertaken in the first pages of the text, as Kircher did in the *Magnes*; instead, he used these arguments to demonstrate how ineffective the medieval scholastic tradition was in describing or understanding light, with the added implication that modern, Peripatetic explanations suffered from the same problems. One might go further, too, and argue that this sort of dismissive attitude towards Peripateticism was present as well in the earlier *Magnes*, which hurried through a standard Aristotelian disquisition on magnetism in its opening pages before quietly but firmly abandoning such reasoning for the rest of the book. Kircher had an ambivalent relationship with the censors within the Society, whose approval was required before any work could be published; perhaps these nonchalant gestures towards a conventional Aristotelian philosophy were intended to satisfy the long-standing requirement that the Society adhere to Aristotle in matters of natural philosophy.[34]

If Kircher upheld the philosophy of Aristotle only in letter rather than in spirit, one might link this to a question he posed in the *Ars magna*. If, according to Aristotle, nothing is in the mind that was not first in the senses, "how then," Kircher wondered, "shall we philosophize correctly and fully concerning the fabric of natural things, if we do not know the arrangement of their most hidden parts?"[35] How, in other words, can we base the study of nature on the use of the

[34] On Kircher's fraught relationship with the Jesuit censors, see Harald Siebert, "Kircher and His Critics: Censorial Practice and Pragmatic Disregard in the Society of Jesus," in Findlen, ed., *Athanasius Kircher: The Last Man Who Knew Everything*, pp. 76–101.

[35] Kircher, *Ars magna lucis et umbrae*, p. 834: "Cum enim, iuxta Philosophi illud epiphonema, nihil insit in intellectu, quod in sensu non prius fuerit; quomodo de rerum naturalium fabrica rectè, & solidè philosophabimur, si abstrusissimas partium compositiones nesciamus?"

senses when so much of nature is hidden? We have already seen how Kircher answered this question within the boundaries of his museum, and as part of his discussion of magnetism. In both cases, he suggested that the intervention of artifice could reveal the hidden operations of nature, exposing them to scrutiny by the workings of gears, turnstiles, and mirrors. Here, in the *Ars magna*, he articulated the same idea, for he raised these questions as part of his discussion of the microscope. "So great is the deceit of our senses," Kircher claimed, that we will never arrive at a complete understanding of nature "unless [the senses] are propped up by something."[36] In this case, Kircher placed his hopes in "that divine science of optics."[37]

It is surely no coincidence that on the frontispiece to the *Ars magna*, which portrays four different sources of illumination—sacred authority and reason are at the top, profane authority and the senses at the bottom—the telescope represents the senses. One might read this pictorial schema as upholding a predictable Aristotelian arrangement in which reason is pre-eminent to the senses, emulating closely a similar representation on the frontispiece to Christoph Scheiner's *Rosa Ursina* (1626–1630). In Scheiner's portrayal, the senses—aided once more by a telescope—provided only a clouded and fuzzy picture of sunspots, while the light of reason, illuminated directly by God, depicted these sunspots with perfect clarity. While it is true that Scheiner sought to preserve a Peripatetic epistemology as the foundation of his astronomical work, it is less clear that the frontispiece of Kircher's *Ars magna* presents the argument that the telescope and, by extension, the senses are poorly suited to the investigation of nature; such a claim is difficult to establish from the illustration alone.[38]

Though we might view these Jesuit frontispieces as an explicit indictment of the senses in relation to reason, with the latter always pre-eminent, the relationship between the two was far more complicated for Kircher. This is made clear not only by his unstinting attention to the role of the senses in the acquisition of knowledge, in the *Ars magna* and elsewhere, but also by his clear realization that the exercise of reason is dependent on the senses, most

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[36] Kircher, *Ars magna lucis et umbrae*, p. 834: "Tanta est sensuum nostrorum fallacia, ut ἀδῦνάμία [i.e., weakness] ferè sit ad perfecta rerum naturalium notitiam pervenire, nisi aliquo fulcirentur … "

[37] Kircher, *Ars magna lucis et umbrae*, p. 834: "Haec autem est divina illa Optice scientia, quae quod abditum est è profundissimis tenebris in admirabile lumen educit."

[38] On Scheiner, see William B. Ashworth, Jr., "Light of Reason, Light of Nature: Catholic and Protestant Metaphors of Scientific Knowledge," *Science in Context*, vol. 3, no. 1 (1989), pp. 89–107; Michael John Gorman, "A Matter of Faith? Christoph Scheiner, Jesuit Censorship, and the Trial of Galileo," *Perspectives on Science*, vol. 4 (1996), pp. 283–320.

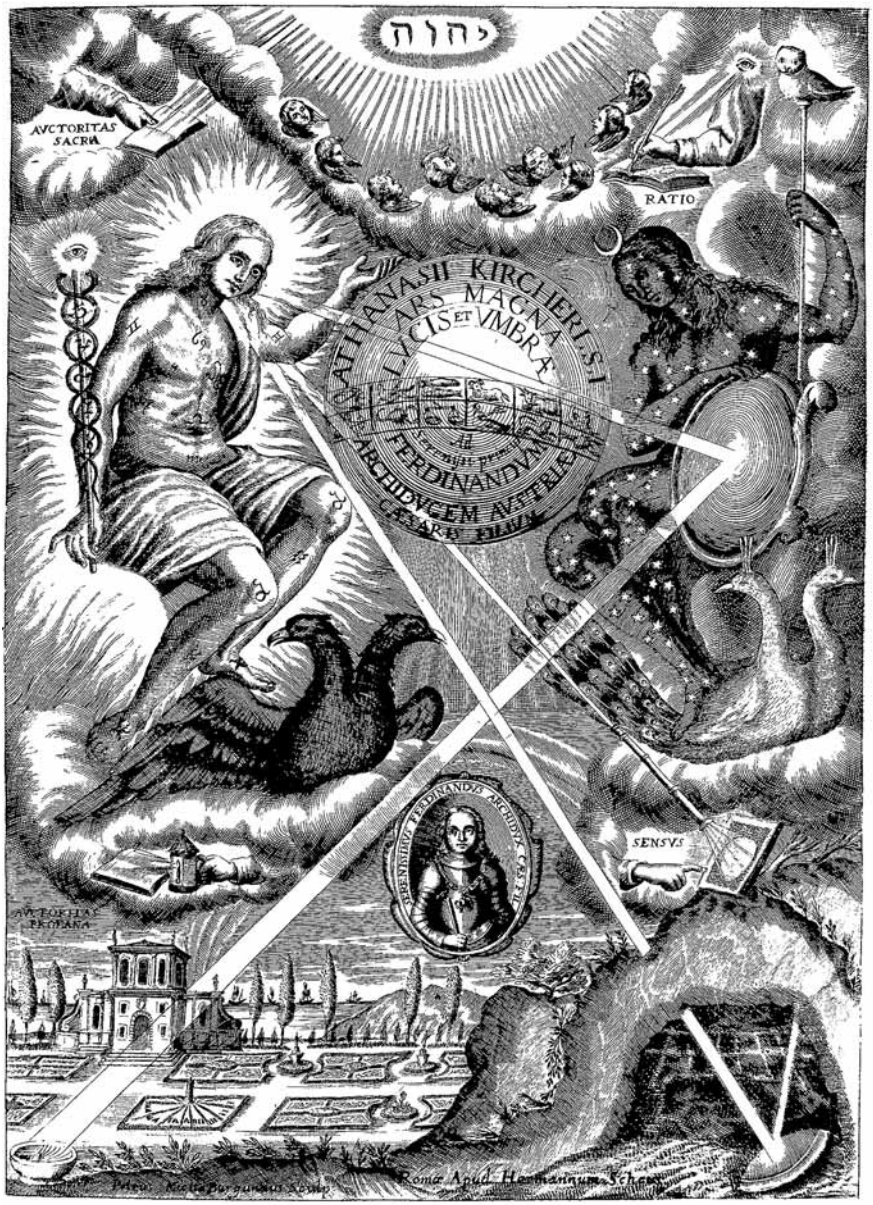

Figure 5.3 The frontispiece to the *Ars magna lucis et umbrae*, showing the four sources of illumination: sacred authority, reason, profane authority, and the senses.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

particularly in the study of nature. Why else would he insist so strongly on "propping up" the senses with the aid of optics and other forms of artifice? His rhetoric throughout the *Ars magna* was no different from that articulated in his museum: if we are to see and understand the workings of nature, artifice must support our senses, whether by actually augmenting our senses, as with the microscope, or by providing a tangible manifestation of processes and forces that would remain otherwise insensible.

Kircher's concerns about the fallibility of the senses dovetailed with an explicit and perhaps surprising lack of certainty in his explanations of light. As part of his discussion of the microscope he stated firmly: "It is indeed absolutely plain that all things seen by many of us are in truth other than what they seem," a reference to the unfamiliar and strange appearance of minerals, plants, and animal hairs under magnification.[39] The microscope, of course, "propped up" his senses and allowed him to witness the true form of things, but Kircher's avowal that things are "other than what they seem" was a stark reminder not only of sensual fallibility, but also of the difficulties inherent in knowing anything at all with certainty.[40]

In fact, Kircher seemed determined in the *Ars magna* to ignore the pursuit of certainty, a determination that he linked explicitly with his reservations about Peripatetic arguments about light and an ostensible lack of patience for the tepid speculation that characterized many such arguments. When he addressed the question of light rays, he noted that Aristotelian philosophers had debated for centuries whether rays were a material substance, or a space, or something else, but he stated bluntly that he himself would not be troubled by such idle speculations: "nevertheless in this perplexing business it ought to be said that I do not know" (*quid in tam perplexo negotio dici debeat nescio*). In other words, he felt free not merely to shrug aside the entire question of what rays were, but to admit happily that he himself had no idea what they were. He went on to add that he would be better off simply concluding nothing at all rather than appearing to contradict either "the new Philosophy" or the assertions made "in the preceding book," by which he may have meant the Aristotelian explanations for light that he had bandied about in the first book of the *Ars magna*.[41] These

[39] Kircher, *Ars magna lucis et umbrae*, p. 834: "quidem luculenter patet omnia a nobis visa multo revera, ac videntur, alia esse."

[40] On the microscope in early modern science, see Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, N.: Princeton University Press, 1995).

[41] Kircher, *Ars magna lucis et umbrae*, p. 111: "in re adeo ardua ego nihil facilè quidquam determinaverim, ne novam Philosophiam mundo obtrudentes, in priori libro assertis contradicere videamur."

were remarkable statements: rather than choosing one explanation over another, Kircher simply opted out, choosing to conclude nothing at all.

The *via media* promoted by Kircher resembled, in its outlines, the epistemology at work in his museum. The Kircherian collection occupied a space somewhere between conventional Peripateticism and other ways of investigating nature—its attention to the Aristotelian virtue of collective assent, for example, was balanced by its unmistakable focus on the singular experience. The *Ars magna*, too, embodied many of these dichotomies, with its traditional authorities dressed up as *Machinamenta* or *Experimenta* and its ironic juxtaposition of Aristotelian logic with a defiant and explicit lack of certainty. At the same time, there were other ways in which the *Ars magna* overlapped with the Kircherian collection—most significantly, perhaps, in the attention paid to spectacle. Indeed, Kircher addressed the potential power of spectacle directly, taking some pains to highlight its utility at several points in the *Ars magna*. This dovetails neatly with the messages offered by the Kircherian museum, which Giorgio de Sepi described as "the epitome of philosophical practice" and which established in turn the importance of spectacle to that practice.

Kircher's emphasis on spectacle as utilitarian rather than frivolous stood in sharp contrast to the claims made by contemporaries later in the seventeenth century, almost all of whom were northern Protestants who maligned his interest in spectacle and wonder as antithetical to sober, "proper" philosophical endeavors. Christopher Wren, for example, once remarked to Lord Brouncker shortly before Charles II was to visit the Royal Society that "to produce knacks only, and things to raise wonder, such as Kircher, Schottus, and even jugglers abound with, will scarce become the gravity of the occasion."[42] Wren deliberately cast Kircher and his disciple Gaspar Schott as "jugglers," more interested in producing wonder in their audiences than in legitimate or proper natural philosophical demonstration. But Kircher had his defenders, too. Robert Moray—who, unlike Wren, had spent time in Catholic Europe—wrote to Henry Oldenburg, secretary of the Royal Society, that "[Kircher] meddles with too many things to do any exquisitely, yet … none goes beyond him, at least as to the grasping of variety: and even that is not onely often pleasurable but usefull."[43] Moray's insistence that the Jesuit father's spectacular displays could be simultaneously useful and pleasurable certainly gave more credit to Kircher than

[42] Michael John Gorman, "From 'The Eyes of All' to 'Usefull Quarries in philosophy and good literature': Consuming Jesuit Science, 1600–1665," in *The Jesuits: Cultures, Sciences, and the Arts, 1540–1773*, John W. O'Malley, S.J., Gauvin Alexander Bailey, Steven J. Harris, and T. Frank Kennedy, S.J., eds. (Toronto: University of Toronto Press, 1999), p. 183.

[43] Gorman, "From 'The Eyes of All'," p. 182.

most contemporaries would otherwise have countenanced, particularly within the confines of the Royal Society. This English squeamishness about spectacle and public display was rooted, at least in part, in a widespread anti-Catholicism that emerged in the late sixteenth century in England and persisted into the seventeenth century. Catholic courts were notorious for their lavish theatrical displays—something Wren should have remembered when wondering how to impress Charles II, who spent much of his exile in both France and Spain—and the Catholic Church and its priests were reviled in England as relying on trickery and superstition in order to defraud their hapless congregations.[44]

For all their seeming distaste for elaborate displays, however, members of the Royal Society exploited spectacle freely when they deemed it necessary. One of the most prominent of the Society's early members, John Wilkins (1614–1672), published an entire book devoted to a "mathematical magick" that resembled nothing so much as the same "magic" endorsed and disseminated by Kircher and his disciples. Wilkins even designed and constructed a "speaking statue" nearly identical to one in the Kircherian collection.[45] Then, too, there were the phosphorus demonstrations engineered by members of the Royal Society in the latter decades of the seventeenth century, elaborate public-relations exercises that depended largely upon spectacle and wonder. Members of the Society invited other virtuosi as well as women and children to a variety of demonstrations in the 1670s and 1680s, many of them chemical in nature.[46] Such demonstrations were an integral part of the Society's attempts to inculcate a public culture of science, as well as to advertise their own collective acumen. Phosphorescent substances, of course, were well-suited to such spectacles: they were rarities and thus exotic, while also capable of exciting the senses of an attentive audience.

Members of the Royal Society professed themselves to be leery of depending too greatly upon spectacle, however, which could pose a "moral danger" if "observers [are] diverted into the simple gratification of the senses and hence … fail to progress to the stage of judgment and ratiocination." Thomas Sprat, who chronicled and codified the ideals of the early Royal Society, claimed in his *Historie* (1666) that the Society "spurned the examination of monstrous,

[44] Rob Iliffe, "Lying Wonders and Juggling Tricks: Religion, Nature, and Imposture in Early Modern England," in James E. Force and David S. Katz, eds., *Everything Connects: In Conference with Richard H. Popkin* (Leiden: Brill, 1999), pp. 205–9.

[45] On the English tradition of "mathematical magic," see J. Peter Zetterberg, "The Mistaking of 'the Mathematicks' for Magic in Tudor and Stuart England," *Sixteenth Century Journal*, vol. 11, no. 1 (1980), pp. 83–97.

[46] J.V. Golinski, "A Noble Spectacle: Phosphorus and the Public Cultures of Science in the Early Royal Society," *Isis*, vol. 80, no. 1 (1989), pp. 11–39.

extravagant, and rare phenomena" for this same reason, though the *Philosophical Transactions* published by the Society would seem to give Sprat the lie.[47] The *Transactions* contained numerous examples of the experimental "science" practiced by members of the Society, but they also communicated no shortage of monstrous births, strange celestial lights, and other typical examples of wonders and marvels—precisely those rare and extravagant things, in other words, that Sprat claimed to abhor.[48]

While Sprat himself perceived some value in the "sensible *pleasure*" excited by experiment, and praised the "most *diverting Delights*" produced by experimental demonstrations that had "power enough to free the *minds* of men from their vanities, and intemperance ... by opposing pleasure against pleasure," the public line taken by most in the Royal Society was that spectacle was acceptable only if it led to a judicious consideration of physical properties or other philosophical material.[49] To cross into the realm of spectacle for its own sake was to engage in the "knacks" and other foolishness of which they deemed Kircher particularly guilty. Circling back to the *Ars magna*, however, we find Kircher himself suggesting that philosophers should exploit the spectacular nature of phosphorescent substances in order to excite the admiration and interest of an audience. Moreover, he made this suggestion some thirty years before the Royal Society began performing their public demonstrations with phosphorus. In a section entitled, *De Photismo Lapidum; De Lapide Phenggite, seu Phosphoro minerali*, Kircher explained that rarities like phosphorescent substances could "vehemently excite" the study of causes and effects, and that the examination of "things new and rare" produced a wide range of opinions.[50] What he described was not spectacle for its own sake; it is clear that he endorsed the use of wonder and spectacle in "exciting" study and philosophical contemplation, precisely the line taken decades later by Wren, Sprat, and their contemporaries in England.

Kircher's disquisition on the utility of spectacle fits perfectly into both the *Ars magna* and his wider epistemology. One can read the *Ars magna* as an extensive

[47] Golinski, p. 24.

[48] Lorraine Daston, "The Language of Strange Facts in Early Modern Science," in Timothy Lenoir, ed., *Inscribing Science: Scientific Texts and the Materiality of Communication* (Stanford: Stanford University Press, 1998), pp. 21–31.

[49] Thomas Sprat, *The History of the Royal-Society of London for the improving of natural knowledge* (London, 1667), pp. 343–4.

[50] Kircher, *Ars magna lucis et umbrae*, pp. 26–7: "Huius igitur lapidis prodigiosi spectacula, uti maximam apud Philosophos excitarunt admirationem, ita animos quoque multorum illa luce sua mirabili, ad tam rari effectus causam omni studio vehementer accenderunt; unde quidem, uti in rebus novis & raris fieri solet, variae emerserunt variorum opiniones."

commentary on both seeing and knowing, and spectacle in itself certainly overlaps with both of those concerns. The magnetic machines and catoptrical devices scattered throughout both Kircher's collection and the pages of his books were designed and displayed precisely because, as spectacles, they could excite interest and encourage contemplation. The irony here is that Kircher used a book about light and vision to undermine the sensual foundations of natural philosophy, and ultimately to question whether observation in itself could ever establish certainty. At the same time, however, he provided his readers with ways to circumvent the frailties and failings of their senses: pieces of artifice that might support the exercise of the eyes, the twinned practices of spectacle and bemusement as incitement to philosophical investigation, and novel, probabilistic approaches to the most basic of philosophical problems.

The *Mundus subterraneus*[51]

The study of geology became a preoccupation for a range of early modern thinkers in the latter decades of the seventeenth century, and only increased in popularity into the eighteenth century.[52] Amidst this growing interest, Kircher's *Mundus subterraneus* remains an influential example of seventeenth-century theories about the subterranean realm. We know that it was awaited with some eagerness in England, where Henry Oldenburg, then secretary of the Royal Society of London, relayed news of its impending publication in a letter to Robert Boyle in August of 1664; Kircher's publisher in Amsterdam had assured Oldenburg that it would be printed "within six weeks."[53] Once it appeared in London the following year, Oldenburg wrote again to complain of the expected cost—"50 shillings at least, and yet but one volume," he lamented—and after seeing it for the first time, commented in yet another letter to Boyle, "I doe much feare, he gives us rather

[51] Portions of this section appeared in Mark A. Waddell, "The World, As It Might Be: Iconography and Probabilism in the *Mundus subterraneus* of Athanasius Kircher," *Centaurus*, vol. 48 (2006), pp. 3–23, and are reproduced with permission.

[52] For background on early modern geology, see Gary D. Rosenberg, ed., *The Revolution in Geology from the Renaissance to the Enlightenment* (Boulder, CO: Geological Society of America, 2009); Gian Battista Vai and William Cavazza, *Four Centuries of the Word Geology: Ulisse Aldrovandi 1603 in Bologna* (Bologna: Minerva Edizioni, 2003); Rhoda Rappaport, *When Geologists Were Historians, 1665–1750* (Ithaca, NY: Cornell University Press, 1997).

[53] Henry Oldenburg, *The Correspondence of Henry Oldenburg*, ed. A. Rupert Hall & Marie Boas Hall, vol. 2 (Madison: University of Wisconsin Press, 1966), p. 207.

Collections, as his custom is, of what is already extant and knowne, than any considerable new Discoveryes."[54]

Oldenburg ultimately deferred to Boyle in judging the merits of Kircher's work, though he wrote to Benedict Spinoza in October of 1665 that "although [Kircher's] arguments and theories are no credit to his wit, yet the observations and experiments there presented to us speak well for the author's diligence and for his wish to stand high in the opinion of philosophers."[55] In fact, members of the Royal Society were willing to attempt some of the experiments described in the *Mundus*. Oldenburg wrote to Robert Moray in November of 1665 that Kircher's theories on the tides were especially interesting: " ... he produces severall Experiments to evince, that the Moon is the sole cause of those Sea-reciprocations, by a Nitrous quality and Dilating faculty, he hath found in her: of which Experiments it will perhaps be worth while to make trialls ... "[56] Boyle himself wrote that he intended to test Kircher's ideas "concerning the Ebbing & flowing of the sea," but a few days later he reported that "the Expt about Salt & Nitrous water exposd to the Beames of the moone did not succeed as Kircher promises, but as I foretold."[57] Oldenburg's reply said only, "'Tis an ill Omen, me thinks, that the very first Experiment singled out by us out of Kircher, fails, and it 'tis likely, the next will do so too."[58]

The inability to replicate Kircher's claims may have done some damage to his reputation in England, though it was true that experiment was an uncertain business in the seventeenth century; the trials made by members of the Royal Society were not necessarily nor easily replicated themselves.[59] A review of the *Mundus* appeared in the Society's *Philosophical Transactions* in the same year as Boyle's failed experiments and spoke of it as a search into "the recesses of Nature" as well as emphasizing Kircher's study of "the Great Secrets of Nature," but otherwise passed no particular judgment on the work.[60] Modern commentators have been less kind; one scholar claimed recently of the *Mundus* that "[Kircher]

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[54] Oldenburg, pp. 512, 532.

[55] Oldenburg, p. 540.

[56] Oldenburg, p. 592.

[57] Oldenburg, pp. 604, 613.

[58] Oldenburg, p. 615.

[59] Paula Findlen, "Scientific Spectacle in Baroque Rome: Athanasius Kircher and the Roman College Museum," in Mordechai Feingold, ed., *Jesuit Science and the Republic of Letters* (Cambridge, MA: MIT Press, 2003), p. 259.

[60] Anonymous, "Of the Mundus Subterraneus of Athanasius Kircher," *Philosophical Transactions*, ed. Henry Oldenburg, vol. 1 (1665), pp. 109–17.

simply fills pages and pages with descriptions of a bewildering variety of novelties without any coherent synthetic explanation."[61]

A close examination of the *Mundus*, however, reveals that Kircher used this particular work to encourage a meaningful and intellectual contemplation of the hidden depths of the Earth through a mix of iconography and probabilism, presenting to his audiences a speculative glimpse of the world as it might be. Here, then, is the coherence that has eluded some historians: not a coherence of explanation, but one of method and epistemology. More than merely a "bewildering variety of novelties," the *Mundus subterraneus* actually worked in many respects like Kircher's earlier *Magnes*. Similarly to his work on the magnet, the *Mundus* also emphasized the underlying unity between things, most prominently between the natural and the artificial. Using the Earth as his focal point, Kircher spun an elaborate and complex web of correspondences and links between a wide array of disparate subjects and phenomena, everything from complex machines designed to pull fresh air into mines and fill rooms with pleasing scents to descriptions of dragons, demons, and giants.

The structure of the *Mundus* remains largely unexplored by historians, perhaps because so few see it as anything more than a collection of unconnected miscellanies. Kircher, however, created a series of narrative dichotomies that simultaneously juxtaposed and opposed the ideals of Art and Nature, knowing and doing, contemplation and action, and these dichotomies guide the attentive reader to a contemplative and speculative consideration of both the hidden interior of the world and its utilization and exploitation by humanity. Alongside the iconography and imagery that appears throughout, the structure of the *Mundus* works to transform this text into, again, something very like a meditative compendium of those hidden depths. Its purpose was to encourage the imaginative contemplation of the unseen rather than to inculcate a culture of direct observation and experimental precision, something that puts Kircher at odds with the intellectual culture developed by institutions like the Royal Society and that explains, at least in part, why Kircher's work has been so frequently misunderstood.

Structurally, Kircher divided the *Mundus* in two. Volume I focused on "the admirable structure of the terrestrial globe,"[62] and consequently described that structure in great detail, exploring mountains and volcanoes, the oceans of the world (including the first detailed maps of ocean currents), the structure of underground springs, and meteorological phenomena caused by terrestrial

[61] Louis Caruana, "The Jesuits and the Scientific Revolution," in Thomas Worcester, ed., *The Cambridge Companion to the Jesuits* (Cambridge: Cambridge University Press, 2008), p. 254.

[62] Athanasius Kircher, S.J., *Mundus subterraneus*, 3rd edn, vol. I (Amsterdam: Joannem Janssonium & Elizeum Weyerstraten, 1678), p. 55.

exhalations. In short, this first volume focused on Nature itself, and on the contemplative, philosophical knowledge of natural processes and phenomena. Volume II, by contrast, focused on the "fruits of the Earth" and their exploitation by humanity. Kircher discussed the work of Nature-as-artisan in the production of gemstones and fossils as well as the human artisan's production of colored stones and artificial gems, before enumerating at length the varied properties of minerals and metals and their uses in the production of medicines, dyes, and other practical products. Kircher also treated alchemy at length, alongside images of chemical furnaces that he himself designed and used in the Collegio Romano. This volume, then, exulted the active pursuit and utilization of Art. Further dichotomies drawn throughout the text underscored the importance not only of establishing a balance between the disparate realms of Nature and Art, moving from one to the other in the pursuit of both natural knowledge and artisanal control, but also of the accumulation of the probable through individual contemplation and the artificial imitation of nature's hidden realms and forces.

For Aristotelians, the imitation of nature was generally unproblematic; it was a medieval commonplace that "art is the ape of nature." Aristotle, in his *Physics*, had taught that "the arts either, on the basis of Nature, carry things further [*epitelei*] than Nature can, or they imitate [*mimeitai*] Nature."[63] There is evidence, however, that, over the course of the seventeenth century Aristotelian thinkers increasingly turned their attention to the idea that art could do more than merely imitate nature.[64] In fact, the possibility that art could "carry things further" than nature—that is, that it could perfect natural processes—played a vital role in early modern ideas about experimentalism and permitted some prominent Aristotelians to embrace experiment as a legitimate means of acquiring knowledge about natural processes.[65] Kircher himself was ambivalent about this aspect of art, at least as concerned things such as the alchemical transmutation of metals, which he deemed impossible and potentially impious (an opinion he shared with the Jesuit commentators at Coimbra).[66] What interested him more was the artificial imitation of natural phenomena, and in the *Mundus* he sought

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[63] William R. Newman, *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (Chicago: University of Chicago Press, 2004), p. 17.

[64] Dennis Des Chene, "Forms of Art in Jesuit Aristotelianism," in Bernadette Bensaude-Vincent and William R. Newman, eds., *The Artificial and the Natural: An Evolving Polarity* (Cambridge, MA: MIT Press, 2007), p. 136.

[65] See, for example, Newman's discussion of Daniel Sennert in both his *Promethean Ambitions*, esp. pp. 252–4, and his *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006).

[66] Des Chene, pp. 140–42.

to convince his readers that two separate forms of imitation—the experimental emulation of subterranean processes, and the pictorial representation of what lies hidden beneath our feet—could aid, or even replace, the philosophical contemplation of the hidden depths of the world.

Dichotomies and oppositions permeate the *Mundus*, a fact that was made clear in the respective dedications of the two volumes. Kircher dedicated the first volume to Pope Alexander VII, and therein he spoke of "a road into the inferior parts of the Earth," assuring the pontiff that, like the Cynic philosopher Diogenes, he would orient himself with reference to Alexander's pious light so that he might describe clearly the shadows that block our sight of the Earth's interior and avoid their "trampling underfoot [his] wandering and labors."[67] There were, in fact, numerous references to shadows throughout the *Mundus*, just as there had been in both the *Magnes* and the *Ars magna*. Kircher repeatedly promised to take his reader through these shadows and into the most hidden and innermost depths of the Earth so as to see clearly what lay beneath, relying on contemplation and reasoning in his attempts to do so. This was a pious and philosophical endeavor, the study of God's work and its "admirable structure," thereby framing the investigation of nature as both intellectual and spiritual.

The first volume also ended on a spiritual note. In the brief *conclusio*, Kircher framed his investigation of the interior of the Earth in a religious language, speaking of the "hidden temple of the Geocosmos" (*occulta Geocosmi sacraria*) and noting that, having struggled "to burst forth from the horrid and inaccessible abysses of the subterranean world," all that remained was to offer thanks to God, whose innumerable marvels resided even in the "hidden abysses" of the world.[68] The impressions Kircher presented in this first volume, of the pious and faithful Jesuit traversing the deep shadows of the underworld in his quest for truth and enlightenment, permit us to understand his *Mundus* as a spiritual as well as a philosophical journey through the subterranean world. The themes were those of contemplation and *scientia*, emphasized most particularly by an emblematic and figurative iconography of the Earth's interior that worked, as we shall see, to guide the reader on precisely the contemplative journey that Kircher himself articulated.

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[67] Kircher, *Mundus subterraneus*, vol. I, *Dedicatio*, p. ii: "ad cuius lucem possim tenebras illas describere luculenter, ne tenebrae conculcent me in labyrintho inferioris Mundi errantem & laborantem, id est, maius dolium versantem, quam aliquando ingressus fuerit, versaritque Diogenes."

[68] Kircher, *Mundus subterraneus*, p. 345: "Eluctantibus tandem nobis ex horridis inaccessisque Mundi Subterranei abyssis, nil restat amplius, nisi ut converso ad Coelum vultu debitas Tibi gratias reddamus, qui uti solus mirabilia, quorum non est numerus, facis in coelo, terra, mari, abditisque eorum abyssis."

The second volume of the *Mundus*, by contrast, was cast as a celebration of humanity's mastery over God's handiwork, a change in tone that manifested itself, again, in a dedication to a powerful patron. While he had dedicated the first volume to the pope, however, Kircher chose to dedicate the second to Leopold I, Holy Roman Emperor from 1658 to 1705. Kircher opened his dedication to the Emperor by celebrating the tributes Leopold had received "from every part of the terrestrial sphere" and praising his victories, all of which would lead to the Emperor's eventual rule over the entire world. Kircher then cleverly adapted these allusions to worldly domination to the subject of his own work, offering Leopold the *Mundus* as a tribute that would grant him mastery of the interior of the Earth so that his dominion over the terrestrial sphere would be total.[69]

Kircher also promised Leopold that the *Mundus* would act as both book and mirror, and that by looking within, the Emperor would see into the most profound depths of the Earth "by means of a sharp penetration of the eyes."[70] This rhetoric, in which the *Mundus* became simultaneously a reflection of the Earth's hidden depths and the device that permitted the Emperor to penetrate with his eyes to the very core of the world, is significant. What Kircher promised Leopold was not a pious journey through obscuring shadows that would be guided and directed by the light of faith, as he did with Alexander, but rather, the ability to uncover the hidden depths of the world for himself, with allusions to mastery and dominion over those depths. This theme stretched throughout the second volume, with its emphasis on "the fruits of the Earth" and humanity's manipulation, utilization, and mastery of them.

By choosing the pope and the emperor as patrons of the *Mundus*, Kircher shaped a significant dichotomy between spiritual and temporal power, praising both as worthy of respect and admiration but also claiming that each was suited to a particular approach. One could certainly extend the analogy to the opposing realms of Art and Nature, or even contemplation and experiment. When addressing Alexander, Kircher emphasized the importance of contemplation and knowledge, framing his endeavor as a solitary journey through shadow that the dual virtues of faith and reason both illuminated and guided. When speaking to Leopold, however, Kircher emphasized the importance of action and mastery: he not only praised the emperor's worldly and temporal actions and celebrated their triumphant and victorious outcomes, but also urged Leopold to use this text to seek out the depths of the Earth and thereby come to control them.

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[69] Kircher, *Mundus subterraneus*, vol. II, *Dedicatio*, p. i.

[70] Kircher, *Mundus subterraneus*, p. ii.

The dichotomy that Kircher created with the *Mundus* revolved around a number of simultaneous divisions: spiritual/temporal, contemplative/active, knowing/doing. These divisions were themselves subsumed within the central dichotomy that explicitly structured the whole of the *Mundus*, the division between Art and Nature, between the handiwork of God in Volume I and the handiwork of humanity in Volume II. Kircher thus shaped the structure of the *Mundus* in this fashion:

Volume I	**Volume II**
Natural	Artificial
Contemplative	Active
Knowing	Doing
Scientia	*Ars*
Epistēmē	*Technē*
Spiritual	Temporal
Pope	Emperor

This rhetorical strategy illustrated Kircher's equal commitment to two sets of ideals. More importantly, however, he demonstrated to his audience that, whether we rely upon philosophical contemplation or artificial experiment, our understanding of the subterranean world would remain probable, not "factual." As Kircher would later argue, how could we know that realm with certainty when no one has ever seen it for themselves? It was the same idea he had articulated in the *Ars magna*, when he wondered how we could know anything with certainty if causes and phenomena remained hidden. In the investigation of the subterranean world, certainty was neither possible nor, arguably, desirable.

The inability to sense or experience directly certain parts of the world was a central preoccupation not only of Kircher's, but of Cabeo's as well, and of other Jesuits that included both Gaspar Schott and Francesco Lana de Terzi. Throughout the *Mundus* the careful reader encounters the implicit argument that, in the absence of direct *experientia*, one could employ the contemplative mind as a means of perceiving those things that would otherwise remain "un-experienced" and unknown. The mind depended in turn upon artificial imitations of nature, both experimental and pictorial, much as the meditative practice of the *applicatio sensuum* depended upon visual cues.

Kircher more specifically spelled out his efforts to reveal and expose the hidden through the intervention of experiment and artifice early in the *Mundus*; we might recall that he promised his readers that they would find no occult causes in his text: "There is no occurrence in this work of hidden causes, because experiments made by me have not allowed it."[71] Niccolò Cabeo had resorted to a similar rhetoric almost forty years previously, when he promised that readers of his *Philosophia magnetica* would not have an occult quality "thrust upon" them. Recall, too, that Kircher had claimed in both his *Magnes* and the *Mundus* that occult qualities were "the asylum of ignorance." Like Cabeo, he resolved to explore natural phenomena without reference to "hidden causes" or the occult qualities of conventional Aristotelianism. Kircher also attached particular importance to his own experiments: not only did he take credit for this act of revelation, but he also alerted his audience to the central role of experiment and artifice in what he was attempting to do. The *Mundus*, then, was not intended to work as a purely theoretical revelation of nature's secrets. As the dedication to Leopold made clear, it was in active utilization and practical experimentation that revelation would become possible.

Given the central role of such experiments, we return to the question of why Kircher included experiments that ultimately failed, particularly after he had boasted of their revelatory power. Perhaps Kircher simply failed to try these experiments himself before including them in the *Mundus*, or perhaps their inclusion—tested or otherwise, workable or otherwise—possessed some merit in itself. Assuming for the moment that Kircher was neither negligent nor incompetent (both possible, but difficult to prove and unhelpful in any case) we must focus our attention on the latter possibility: that the experiments and claims described by Kircher possessed, for him, some value beyond their reproducibility by others. The experiment attempted by Robert Boyle concerning the tides failed, but presumably he did much the same thing as Robert Moray, who reported to Oldenburg that he had dutifully filled a basin with water, added both salt and nitrate, and set it under the light of the moon to watch for perturbations that might signal that the water was experiencing a tidal force.[72] So small a trial could hardly capture Kircher's larger achievement in the *Mundus*; he was one of the first to attempt to map tidal currents on a global scale, using reports he received from mariners and fellow Jesuits traveling around the world.[73] Perhaps, then, the value of Kircher's proposed experiments lay not

[71] Kircher, *Mundus subterraneus*, vol. I, *Praefatio Secunda ad lectorem*, p. iii.

[72] Oldenburg, p. 606.

[73] For more on Kircher's attempts to solicit information about the tides, see Michael John Gorman, "The Angel and the Compass: Athanasius Kircher's Magnetic Geography," in

in their ability to capture or codify facts about the world but rather in their ability to spur the mind to a contemplation of what might be possible. Contrary to our expectations, Kircher may have intended his experiments and machines to complement this imaginative contemplation of the probable, not to usurp it with the creation of "matters of fact."

Kircher's probabilistic experiments could also function as directed revelations of hidden natural things, made possible by the imitative power of artifice. Indeed, the notions of imitation and revelation are closely linked, for when one proposes to imitate through art an aspect of the natural world that is hidden, insensible, or otherwise difficult to know, one effectively renders such things visible and knowable, at least as far as artifice will allow. This makes sense when we consider that many of the machines and instruments that Kircher displayed in both his museum and the pages of his texts exhibited in their activity particular natural powers and processes that one could not otherwise observe directly. For example, consider the way in which Kircher describes the art of chemical distillation: as an imitation of nature's subterranean processes.[74] The artisan or chemist who engaged in the act of distilling imitated or duplicated a natural process that normally took place in the subterranean depths, a common trope from alchemical theory and practice that envisioned the purification of metals by the alchemist as an emulation of the same processes that naturally ripened metals within the Earth.[75] The *Mundus* thus presented its readers with the promise that they would not only see the interior of the world in the act of distillation itself but would also be able to duplicate and control its processes through the intervention of ingenuity and artifice.

Artifice may have had a central role in Kircher's project, but the elaborate dichotomy that he created between the artificial and the natural guided the receptive reader, paradoxically, towards a powerful notion of universality, of a single project that sought to bind together a series of disparate, even opposite, ideals in pursuit of a universal kind of knowledge. The Kircherian collection similarly embodied this notion of universality by linking together a host of disparate objects into a single, elaborate *theatrum mundi*. Pervaded by dichotomies as it is, the *Mundus* is no different: it revealed the true nature of the subterranean world only through the juxtaposition of those opposing categories,

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Findlen, ed., *The Last Man Who Knew Everything*, pp. 229–51.

[74] Kircher, *Mundus subterraneus*, vol. II, p. 390: "Artem Distillatoriam esse imitatricem Naturae in subterranea officina seu Ergasterio omnia per distillationem efficientis."

[75] Reiterations of this idea abound in alchemical and chymical texts; for an early example, see William R. Newman, ed., *The Summa Perfectionis of Pseudo-Geber: A Critical Edition, Translation, and Study* (Leiden: Brill, 1997).

by both spiritual contemplation and active experimentation. This text is nothing else but a *theatrum mundi subterranei*.

As both an Aristotelian and a Jesuit, Kircher was well suited to finding a balance between seemingly disparate ideas. As an Aristotelian, he could advocate the use of experiment and artifice in the pursuit of natural knowledge, using Aristotle's own notions of the imitative and perfective arts as the keystone of a scheme in which the natural and the artificial worked together, each reinforcing the other. As a Jesuit, Kircher himself embodied the balance between the contemplative and the active, for this was an integral part of the Jesuit mentality. Consider, for example, the movement from Jéronimo Nadal's meditative images and the solitary contemplation of Christ's life to the active emulation of Christ himself in the apostolic ideals of preaching and charity.[76] Consequently, there were numerous resonances between Kircher's strategies in the *Mundus* and the wider intellectual and spiritual contexts that surrounded both Kircher himself and the larger Society.

More than anything, Kircher wanted audiences reading the *Mundus* to understand that the text itself functioned as an elaborate exercise in revelation. He promised his readers that, like Leopold, they would grasp and ultimately duplicate even the most abstruse and difficult of subterranean processes through "a sharp penetration of the eyes," but he directed their gaze not at the Earth but at the text itself and at its myriad images, which together acted as a mirror in which the secrets of the world might be glimpsed. On the frontispiece of the first volume, Kircher promised both to demonstrate "through strenuous searching" the causes of hidden things deep within the Earth and to explain the utility to mankind of "the joining of Art and Nature." The emphasis here on the "causes of hidden things" pointed to the philosophical timbre of this first volume. Kircher also emphasized the importance of "the varied apparatus of experiments," a somewhat curious turn of phrase that suggested an ever-changing repertoire or "apparatus" of experiments by which Kircher meant to highlight the "necessary utility" to human life of this joining of the natural and artificial.[77]

Similarly, the frontispiece to the second volume promised to place "before the eyes of the curious reader all that is rare, exotic, and portentous contained in the fecund womb of Nature," a clear allusion to the marvelous phenomena

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[76] Walter S. Melion, "Memory, Place, and Mission in Hieronymus Natalis' *Evangelicae historiae imagines*," in *Memory and Oblivion: Proceedings of the Congress of the History of Art* (Dordrecht: Kluwer Academic Publishers, 1999), pp. 603–8.

[77] Kircher, *Mundus subterraneus*, vol. I, frontispiece: "Abditorum effectum causae acri indagine inquisitae demonstrantur; cognitae per Artis & Naturae conjugium ad humanae vitae necessarium usum vario experimentorum apparatu ... "

and properties on which Kircher would focus most particularly in this second volume, with its discussions of dragons, giants, and the playfulness of Nature more generally.[78] But he also stated his desire to "expose the fruits of the subterranean world," the same rhetoric he used in his dedication to Leopold. The references in these frontispieces to the exercise of the reader's gaze—strenuous searching, exposure, being placed "before the eyes"—are more than suggestive. Just as with Niccolò Cabeo, who had promised to put the gaze of his reader to work in the revelation of the magnet's nature, Kircher's challenge now was to engineer a means of making that exercise possible. Again, as with Cabeo and his own, earlier *Magnes*, he turned to iconography.

We must read and interpret the images included throughout the *Mundus* as we do Kircher's experiments: not necessarily as exact or precise renderings of "facts," but rather as imaginative suggestions for further contemplation and as figurative illustrations of deeper truths. In such thinking, Kircher was far from alone; though they did not necessarily use iconography in their own works, contemporary alchemists sometimes illustrated the hidden secrets of alchemical practice with reference to purported experiments that were intended not to describe events that had actually taken place but, instead, to encourage the contemplation of the possibilities inherent in transmutatory alchemy.[79] For Kircher, the images in the *Mundus* functioned, for the most part, emblematically or figuratively, even those for which he may have envisioned a more practical or referential purpose. For example, consider his maps of oceanic tides: encompassing as they did the entire world, they served no real, practical purpose as a tool for navigators. Kircher wanted his readers to grasp not the intricacies of the currents themselves, but rather the idea that vast currents existed and moved through the oceans and that their origins lay in the subterranean realm. In effect, he could have drawn those currents in any way he wished; their precision—that is, the degree to which they reflected reality—was of less importance than what they suggested to the mind of the inquisitive reader.

The imaginative task that Kircher envisioned for his readers is perhaps best exemplified in two large folio depictions of the interior of the Earth, one showing the arrangement of subterranean aqueous canals which feed into the oceans and cause marine phenomena such as whirlpools and vortices, the other displaying a similar vision in which canals of fire snake outwards from the burning core of

[78] Kircher, *Mundus subterraneus*, vol. II, frontispiece: "Quibus mundi subterranei fructus exponuntur, et quidquid tandem rarum, insolitum, et portentosum in foecundo Naturae utero continetur, ante oculos ponitur curiosi Lectoris."

[79] This is an example of what Lawrence Principe calls "chymical optimism;" see his *The Secrets of Alchemy* (Chicago: University of Chicago Press, 2012), p. 158.

the Earth and erupt at the surface in volcanoes. Kircher identified each image as a *systema ideale*, meaning that these were only idealized or supposed depictions of the Earth's interior, but the commentary attached to these images made it clear that each *systema* was intended to portray or make apparent (*exprimit*) the fundamental nature of the Earth's depths. Kircher depended upon these representations to grant himself, and his readers, access to sights and realms that would otherwise remain unseen and unexplored. The "strenuous searching" Kircher proposed in his *Praefatio* was neither a physical descent into the depths of the Earth nor direct contact with the phenomena he described and illustrated. Instead, as articulated by Kircher himself, it was the images and experiments he included throughout the *Mundus* that mediated—that made possible at all—this searching and inquiry. It was in these representations and emulations of the subterranean world that Kircher provoked the reader to consider and contemplate the secret depths of the Earth.

In the caption attached to the rendering of the aqueous channels, Kircher informed the reader, "This figure will teach you better all those things that I could not explain with more diffuse words." He then further emphasized the instructive nature of this image, assuring the reader that those aspects of the "aqueous geocosmos" that could not be gleaned directly from the image would "become clear" through description and rational contemplation.[80] When next discussing his rendering of the fiery depths of the world, Kircher demanded of his readers, "Who indeed has observed this? Who out of mankind has ever penetrated to this place?" before going on to say, "With this diagram we wanted to show only that the bowels of the Earth are full of tunnels and chambers of fire, either as they are shown here or in some other way" (*sive ea jam hoc modo, sive alio*).[81]

Kircher's words here make clear that he was not interested in whether his images had managed to capture exactly the subterranean structure of the Earth. Such large and detailed copper engravings must have been expensive to commission and print, suggesting that Kircher did believe them to be important, but their real value lay in their ability to encourage speculation and consideration. The reader is left to imagine the snaking tunnels of fire and magma

[80] Kircher, *Mundus subterraneus*, vol. I, p. 174: "Sed figura te melius docebit omnia, quam ego fusioribus verbis non explicarim. Vides quoque Subterraneum Orbem, in extima superficie terrae mare camposque subsequi, et haec aërem, uti schema docet; Reliqua exactius ex ipsa operis descriptione et ratiocinio patebunt."

[81] Kircher, *Mundus subterraneus*, p. 180: "Quis enim haec observavit? Quisnam illuc penetravit unquam ex hominibus? Hoc itaque Schemate solummodo ostendere voluimus, Telluris viscera plena esse aestuaris et pyrophylaciis, sive ea jam hoc modo, sive alio, disposita sint."

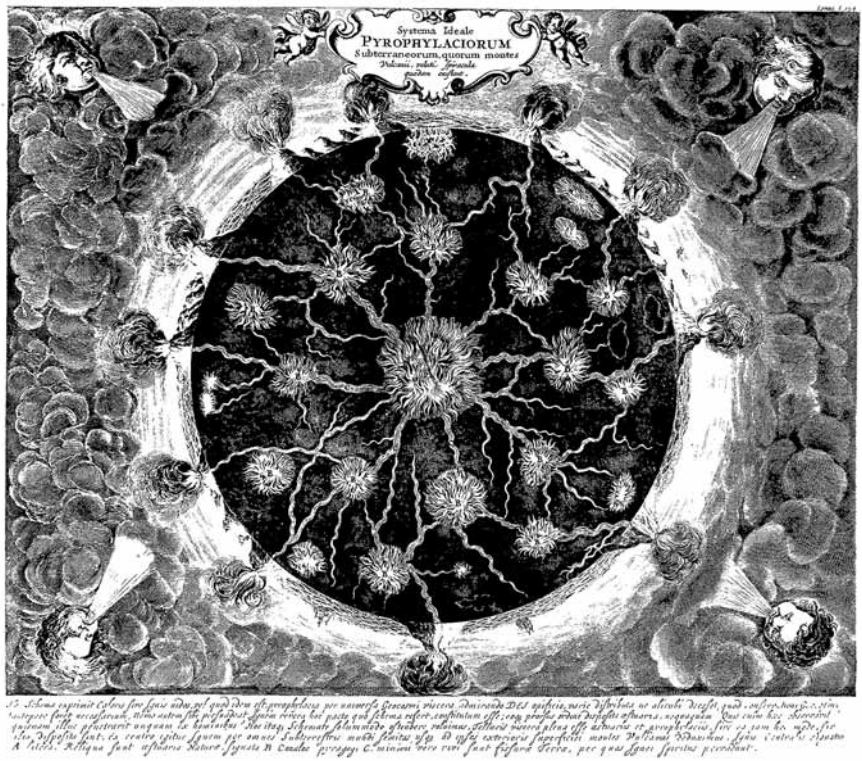

Figure 5.4 A speculative vision of the interior of the Earth, from the *Mundus subterraneus*.

Source: Courtesy Department of Special Collections, Stanford University Libraries.

for himself, providing, one might argue, a more effective portrayal of the subject under consideration than any number of copper engravings. This offers in turn a valuable window on his epistemology, and permits a necessary re-evaluation of both the images themselves and how different audiences may have approached and used them. Kircher did not always intend the artificial devices illustrated in the *Mundus* and elsewhere (for example, in the *Magnes*) actually to work as he himself implied they could, nor did he intend his audiences to understand the intricacies of their operations merely from the images Kircher provided. Instead, these images encouraged the reader to consider and contemplate what might be possible, or in another vein, the deeper truths that lay beneath and behind what these images portrayed—for example, the power of the magnet to unite disparate things, a lesson Kircher eventually turned to a theological purpose

in his *Magnes*. These images operated more as emblems than as literal pictorial expressions of things.

It is likely, however, that some audiences failed to appreciate how Kircher presented his claims. Henry Oldenburg, when he complained to Robert Boyle about the failure of Kircher's experiments, apparently expected a different kind of information, and a different mode of presentation, from the *Mundus*. Perhaps instead he failed to appreciate that one might read the described experiments, like the images that accompanied them, not as simple or literal directions but rather as opportunities for contemplation and speculation.

There is also an intriguing dichotomy at work among some of the images in the *Mundus*, one that further underscores the utility of speculation when confronted by the hidden or unseen. Kircher included depictions of two celestial bodies in the *Mundus*, the moon and the sun. In the case of the former, readers saw a wonderfully detailed rendering of the moon, pockmarked with craters rendered with detail only possible from the use of a telescope. Turning the page, readers then confronted an image of the sun, its surface covered by lakes of fire and mountains belching flame and smoke into the aether.[82] This latter representation was largely speculative; aside from sunspots and solar flares, both of which the Jesuit astronomer Christoph Scheiner had observed and reported, the nature and structure of the sun remained largely a mystery. Nonetheless, the juxtaposition of these two representations was suggestive: the image of one body, already well-documented by 1664 and rendered with the aid of artifice, appeared next to an image that was almost entirely speculative. This juxtaposition might imply to the imaginative reader that, just as one could observe the moon and reproduce its dimensions, the same would eventually be true of the sun, with the subtle and linked implications that the skillful use of artifice would make this revelation possible, and that the Jesuits themselves would be instrumental in its development.

With his depiction of the sun, Kircher gave his audience a glimpse of the unseen; its physical accuracy, like that of the channels of fire portrayed deep within the Earth, was unimportant. Whether or not Kircher had successfully reproduced the structure of the sun was not the primary issue at stake. Instead, it was the implicit argument that we could, and indeed should seek to see this thing for ourselves, gaining "through strenuous searching" a glimpse of what was hidden and a stronger understanding of its nature as a result

The dichotomy between known and unknown, visible and hidden, witnessed and imagined pervaded the *Mundus*. Kircher's goal may have been to encourage

[82] Kircher, *Mundus subterraneus*, vol. I, pp. 62 and 64 respectively.

his audiences to value the speculative and the imagined as a prelude to the visible and understood—in other words, to see speculation and contemplation as the means whereby one moves towards seeing and knowing. Certainly, in his willingness to embrace speculative or probabilistic depictions of natural phenomena, Kircher echoed in the *Mundus* his refusal to depend entirely upon demonstrative certainty as articulated in the *Ars magna*.

When taken together, Kircher's published works were united in their efforts to redefine the study of nature. He was not interested in compiling the "matters of fact" that so appealed to members of the Royal Society, who adhered more to a self-consciously Baconian program of research. The foundation of Kircher's enterprise, his insistence on studying and contemplating the whole of nature rather than slicing its very fabric into a million disparate snippets or "facts," was completely alien to what some, like Boyle and Oldenburg, had in mind. Thus, it is not surprising that they and others dismissed Kircher as little more than a dilettante. Moreover, that he questioned the tenets of Peripatetic epistemology, and that he did so under the noses of the Jesuit censors, demonstrates that, like Niccolò Cabeo, Kircher saw a need to reform some aspects of Peripateticism. His efforts were not as careful as Cabeo's, perhaps, but they may have been more influential, given how widely his works circulated in the seventeenth century.

Kircher challenged his readers to see the world in a wholly unique way. The texts he produced were closer to meditative compendia than to the natural philosophical texts written by many of his contemporaries. Embracing the natural, the artificial, and the supernatural with equal vigor, his works guided their readers to a quiet contemplation of the links between these different realms. When he exhorted his audiences to visualize the depths of the Earth, to contemplate the nature of infinity, or to witness the power of the magnet, he did so by fashioning exercises that joined together the eyes and the mind in a single endeavor, creating a way of knowing that used the same tools and strategies as those found in contemporary meditative exercises. His was an exuberant and compelling vision of a universe rife with wonder, its deepest recesses and hidden secrets waiting patiently for our collective exploration.

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Chapter 6
The Culture of Marvels, Exposed

Some years after serving as disciple and assistant to Athanasius Kircher, Gaspar Schott still carried the indelible stamp of his mentor. He was fond of mentioning Kircher in his own works and of describing, enthusiastically, some of Kircher's more implausible ideas. Unlike his mentor, however, Schott remains largely unknown today. During his lifetime, much of his notoriety came from his association with Kircher: he edited the latter's controversial *Iterum extaticum*, which raised eyebrows among the Society's censors for what some saw as a tacit endorsement of heliocentrism, and he also spent some time working in the Kircherian museum before his superiors sent him back to Germany. From those northern hinterlands, Schott produced a number of texts that clearly bear the hallmarks of Kircher's own intellectual project. In one of these texts, the *Physica curiosa*, we have already seen that Schott pronounced an end to the occult power of the remora; in the *Magia universalis naturae et artis* (1657–1659) and the *Technica curiosa* (1664), he more explicitly considered how to expose the myriad marvels of nature.

Schott's published works contained themes and practices already present in Kircher's own publications, but he did not merely reiterate the ideas of his mentor. Instead, he carried Kircher's ideas further, expanding upon two pre-eminent themes in the Kircherian corpus: the joining of art and nature, and the judicious use of spectacle. Schott's vision of a "universal magic" was both more ambitious and more transgressive than anything proposed by his mentor; while Kircher played with the opposition between nature and artifice, using each to explain and reveal the other, Schott blurred the boundaries between these two realms to such an extent that those boundaries sometimes disappeared entirely. At the same time, Schott played an elaborate and sometimes bewildering game with his audience, presenting phenomena as marvels with one hand while, with the other, exposing these mysteries as commonplace demonstrations of basic natural principles. It was a strategy of presentation not dissimilar to the subtle games at work in Kircher's museum, but was at the same time more extreme in its shuttling between obfuscation and revelation. My argument here is that this movement between hiding and revealing was Schott's response to the prevailing

culture of marvels that had occupied European intellectual inquiry for centuries. The fascination with the rare and unexplained overlapped, unsurprisingly, with phenomena that we have already explored, such as the category of the preternatural. With these things already challenged and scrutinized by natural philosophers across Europe, it was an opportune time for Schott to wrestle with the study of marvels; indeed, with Kircher as his mentor, it would have been surprising had he *not* turned his attention to hidden causes and mysterious effects, as in fact he did in all of his published works.

Marvels and wonders played an important role in shaping how early modern philosophers discussed and understood "scientific" experience.[1] Francis Bacon, for example, incorporated marvels into his evolving system of natural philosophy alongside a host of other "particulars," creating the sort of "preternatural history" in which wondrous (but natural) things became, as part of the Baconian program, merely another way to catalogue and understand the natural world. The Baconian impulse to gather and study such marvelous particulars left its mark on the nascent philosophical institutions like the Royal Society and the Académie Royale des Sciences, both of which collected and published reports of marvels well into the eighteenth century. That the study of marvels slowly disappeared from natural philosophy is indisputable, though why it happened remains a point of contention among historians, as we saw in Chapter 1. Ultimately, the decline of marvels probably had more to do with their being stripped of their cultural currency, and thus of relevance, than any proto-scientific movement to "disenchant" nature.[2]

At a glance, Schott presents something of a paradox. Though he immersed himself unabashedly within the culture of marvels, I will demonstrate that his primary interest lay in the demise of mystery, not its perpetuation. In this, he joined the ranks of contemporary "preternatural philosophers" who "understood their mission in Aristotelian terms: to explain away wonder. Theirs were to be the Herculean labors of a natural philosophy that quenched wonder with knowledge."[3] These preternatural philosophers thought of themselves as the "sworn enemies of wonder" who embraced the dictum that "knowledge of causes destroys wonder," but it would be misleading to pretend that Schott was

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[1] Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998), p. 220.

[2] Lorraine Daston, "The Nature of Nature in Early Modern Europe," *Configurations*, vol. 6 (1998), pp. 149–72.

[3] Lorraine Daston, "What Can Be a Scientific Object? Reflections on Monsters and Meteors," *Bulletin of the American Academy of Arts and Sciences*, vol. 52, no. 2 (1998), p. 45.

an enemy of wonder.[4] Like his mentor, Schott was determined to exploit wonder in order to educate his audiences; he wanted his readers to marvel at insensible forces and causes before being taught how to understand them. At the end of his eclectic, encyclopedic works the only real object of wonder that remained was not the myriad marvels of nature but the ineffable power of the God that had fashioned them.

This ultimate goal may have been why Schott spent relatively little time worrying about the ontological distinction between the natural and preternatural that so occupied other contemporaries. This was replaced in his philosophy by the distinction between nature and artifice, illuminated over and over again by myriad acts of revelation. In this respect Schott resembled the "professors of secrets" who, decades earlier, had worked to expose the secrets of art and nature to audiences across Europe. These "professors" published their secrets as part of an effort to produce a more public kind of science and expose "the tyranny of cunning" in a way that brought "the reign of secrets to an end."[5] But while Schott may have embraced a more public science, he was at the same time wholly committed to, if not "the tyranny of cunning," then at least a more playful and quixotic revelation of secrets than anything contemplated by these earlier "professors."

We have seen that Kircher celebrated the use of experiment and, in at least some respects, participated in the changes sweeping through the intellectual culture of his day even as he continued to rely on traditional sources of authority. Schott, however, differed from his mentor in that he more self-consciously borrowed from different philosophies of nature, and appears to have been more interested in the activities and ideas emerging from the experimental philosophies after the middle of the seventeenth century; he corresponded with Otto von Guericke (1602–1686) on the subject of his pneumatic experiments, for example, and devoted considerable space in his works to the demonstration and explication of novel technologies and methods. While this was in keeping with the practices of other German Jesuits, who were generally willing to embrace the experimental philosophy of the late seventeenth century, this is not to say that Schott necessarily agreed with the philosophical interpretations advanced

[4] Daston, "What Can Be a Scientific Object?," p. 45.

[5] William Eamon, "Science and Popular Culture in Sixteenth Century Italy: The 'Professors of Secrets' and Their Books," *Sixteenth Century Journal*, vol. 16, no. 4 (Winter 1985), p. 484. See also his *Science and the Secrets of Nature* (Princeton, NJ: Princeton University Press, 1996).

by contemporaries such as Von Guericke or Robert Boyle.[6] In the case of these pneumatic experiments, for example, he stopped short of endorsing the existence of a true vacuum. Ultimately, Schott appears to have divided his philosophy between the measured and experimental revelations of nature embraced by contemporary Baconians and the baroque constructions of his idiosyncratic mentor. Indeed, this may be a good way of understanding Schott's similarly idiosyncratic philosophy: the evolving sensibilities of the "new philosophies" filtered through the lens of spectacle, baroque artistry, and playful obfuscation.

Because Schott's works have received so little attention from historians, my analysis here will be thorough in order to show that his idiosyncratic preoccupation with the secrets of nature permeated these texts, and that no matter how eclectic and wide-ranging their contents Schott's chief desire was to reveal those secrets. At the same time, I will demonstrate that he disguised his revelatory intentions behind a façade of pseudo-marvels, time and again erecting elaborate veneers of mystery that he then systematically and carefully demolished. An attentive reading of Schott's works cannot fail to notice that his so-called marvels ultimately went the way of the remora—namely, nowhere. In reading these works, we are witnessing the demise of the marvelous.

Midwife to a Universal Magic

In some ways, Schott was as idiosyncratic a figure as Kircher himself, and possessed of a playful character that led to clashes with his superiors in the Society. When Schott published a short work entitled *Joco-seriorum* in 1662, he did so without first seeking approval from the Society's censors, a blatant breach of the order's rules. The Society's General, Oliva, reprimanded Schott and ruled that the work did not meet the standards expected of the Society's authors.[7] This is unsurprising, perhaps, as the *Joco-seriorum* was mainly concerned with magical tricks and frivolous anecdotes such as "how to stab the head of a chicken so that it might remain alive"—a description of how one might attach the head of a chicken to a table with a knife without killing the unfortunate animal.[8] Despite Oliva's unhappiness with the work its publisher reprinted it in 1666,

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[6] Marcus Hellyer, *Catholic Physics: Jesuit Natural Philosophy in Early Modern Germany* (Notre Dame: University of Notre Dame Press, 2005), p. 7.

[7] Hellyer, p. 44.

[8] Gaspar Schott, S.J. (attr.), *Joco-seriorum naturae et artis, sive magiae naturalis centuriae tres* (Frankfurt am Mayn: Cholinus, 1667), p. 26: "Pulli caput perforare, ut vivus maneat."

the year of Schott's death, as *Joco-seriorum naturae et artis*, though it appeared under a pseudonym. It would go through several later editions as well as at least one German translation.

Though the *Joco-seriorum* was a work of pure frivolity, there are other, more pertinent elements of Schott's thought that evince an equally unorthodox approach to the pursuit of natural knowledge. As part of his multi-volume *Magia universalis naturae et artis* he included a dedicatory poem composed by another Jesuit, Nicolaus Mohr, dedicated to St. Francis Xavier, the archetype of the Jesuit missionary. Mohr claimed of Xavier that "there was nothing unknown that he did not seek out, nothing inaccessible that he did not penetrate. ... He illuminated secrets."[9] Schott himself referred to Xavier as "the great apostle of the Indies, the wonder-worker" (*magno Indiarum apostolo, thaumaturgo*) and also as *Sancto Thaumaturgo*, the saintly wonder-worker.[10] This characterization of Xavier as a thaumaturge or wonder-worker fits neatly into Schott's wider project, focused as it was on the use of spectacle and on Schott's own wonder-working. Thus, we come to grips here not only with Schott's identity as a Jesuit, confirmed by this focus on one of the Society's most famous figures, but also with the wider project that played out in this and his other works. Linking the practice of wonder-working with the penetration of the inaccessible and the illumination of secrets through the figure of Xavier, Schott also defined his universal magic as the joining of art and nature, thereby arguing that it was only in the mingling of the two that we might come to see, understand, and manipulate the secrets of the natural world. The full title of the *Magia* promised to demonstrate "the hidden science of natural and artificial things by which, through the varied application of actives with passives, the spectacular effect of wonders and the miraculous invention of secret things are brought forth for the varied uses of human life." This emphasis on "the uses of human life" reflected a pragmatic tone, and suggests that there was a utilitarian motivation to Schott's works that some historians have ignored.[11]

In terms of ambition, Schott's *Magia universalis naturae et artis* easily rivals the grandiose and lavish works produced by Kircher. The "magic" envisioned by Schott, focused as it was on the illumination of nature's mysteries and the

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[9] Gaspar Schott, S.J., *Magia universalis naturae et artis; sive, Recondita naturalium et artificialium rerum scientia, cuius ope per variam applicationem activorum cum passivis, admirandorum effectum spectacula, abditarumque inventionum miracula, ad varios humanae vitae usus, eruuntur*, 2nd edn (Bamberg: Joannem Arnoldum Cholinum, 1676), vol. IV, p. ii.

[10] Schott, *Magia universalis*, vol. IV, *Dedicatio*, p. i.

[11] See, for example, R.J.W. Evans, *The Making of the Habsburg Monarchy, 1550–1700: An Interpretation* (Oxford: Clarendon Press, 1979), p. 344.

joining of art with nature, also shared numerous similarities with Kircher's own intellectual projects. Though he rehearsed the standard definitions for both natural and demonic magic (and, as we have seen, discussed the existence of demons as part of his later *Physica curiosa*), Schott himself was untroubled by concerns about demonism or diabolism; his universal magic was resolutely natural in its causes, as indeed was that of Kircher. Schott, however, was far from ignorant of the controversies that sometimes attached themselves to contemporary theories of magic. Indeed, the first pages of the *Magia universalis* were an attempt to rehabilitate the very word "magic," which, he informed his readers, was hated by many: "on being heard, ears and souls should be horrified, and if they should discern this same thing [i.e., magic] in a book so inscribed, it should be rejected immediately, and they should sentence it to be consigned to the flames."[12] He then mused on the possibility of substituting "a less odious vocabulary" to discuss the same thing, adding, "I should confess to having finally detached the Epigraph of *Magic* and restoring in its place *Thaumaturgum Physico-Mathematicum*."[13] His solution was an economical one: simply replace a word that carried too many negative connotations with a phrase that did not. Moreover, it was a phrase that connected wonder-working with the term "physico-mathematics," which had been used by Descartes to denote the study of physical causes "formulated in mathematical terms," and which remained popular in natural philosophical treatises of the latter seventeenth century.[14] Thus, it would seem that Schott's universal magic was an attempt to reconcile preceding and contemporary traditions of natural magic with the shifting outlines of the "new science" emerging in the seventeenth century.[15]

Contemporary Jesuits, as we know, took a keen interest in questions of ontology, especially where those questions involved insensible causes. Schott was no exception, though the ontological component of the *Magia* lay primarily in his attempts to determine the boundaries of the natural world. He promised his

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[12] Schott, *Magia universalis*, vol. I, p. 8: "Magiae nomen in tantum apud multos his etiam temporibus versum est odium, ut eo audito horrescant aures & animi, & si quem librum eodem insignitum conspiciant, explodendum confestim, ac flammis devovendum judicent."

[13] Schott, *Magia universalis*, vol. I, pp. 8–9: "Et ut quod res est, fatear, refixi aliquando Epigraphen *Magiae*, eiusque loco *Thaumaturgum Physico-Mathematicum* reposui ... "

[14] Alan Chambers, "Intermediate Causes and Explanations: The Key to Understanding the Scientific Revolution," *Studies in History and Philosophy of Science Part A*, vol. 43, no. 4 (December 2012), p. 554. See also Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), pp. 168–79.

[15] Martha Baldwin, "Alchemy and the Society of Jesus in the Seventeenth Century: Strange Bedfellows?" *Ambix*, vol. 40, part 2 (July 1993), p. 59.

readers that, by making manifest those boundaries that might have been unclear, artifice could lessen or remove altogether the obfuscating power of the invisible or hidden parts of nature, as well as their ability to obscure the ontological boundaries of the natural. Schott's thinking here had deep roots in Peripateticism and its sometimes fraught relationship between art and nature. His *Magia* suggested that, as artifice imitated and perfected the natural, it simultaneously demonstrated what the natural was, for art can never transgress the boundaries of nature. Thus, in its very operation, art comes up against those boundaries and exposes them to our collective view. This, then, was an exercise in ontological clarity, not dissimilar to those published by other Jesuits earlier in the century.

Some of Schott's first words in the *Magia* clarified for his readers the pre-eminence that he ascribed to the study of this "universal magic" and its position in relation to the arts and sciences: "The magic of art and nature [is] the apex of all the sciences, the flowering of art, the discovery of secret things, the making of wonders, to which all arts, all sciences, are made servants."[16] What becomes clear throughout the succeeding dozen pages is Schott's belief that it was the subjugation of a unified art-and-nature to his notion of a universal magic that lent the latter such utility and force, a claim echoed in the *hymenaeus* or marriage song dedicated to "the marriage of art and nature" (*conjugio artis et naturae*), a contribution composed by one Georgius Philippus Harsdorfferus, a "republican councilor" of Nuremberg.

Next was the *Prologus Encomiasticus ad Lectorem*, a lengthy poem composed by the same Nicolaus Mohr who had composed the dedicatory poem to St. Francis Xavier. Mohr's "prologue" at the beginning of the *Magia* also emphasized the joining of art and nature, and characterized Schott himself not only as "the greatest disciple of Athanasius Kircher" but also as *Obstetricans* or midwife to the progeny of a conjoined art and nature, presumably Schott's vision of a universal magic.[17] Mohr further characterized this progeny as "that art which does not surpass the limits of nature" (*Ars Naturae limites non egreditur*),[18] a significant though unsurprising remark echoed by Mohr's later assertion that "[Nature] teaches itself to be limited through Art, not to be transformed; to be directed, not to be corrected; to be lifted up, not to be cast down" (*limitari se per Artem docet, non immutari; Dirigi, non corrigi, elevari, non depravari*).[19] The

[16] Schott, *Magia universalis*, vol. I, *Dedicatio*, p. i: "Artis et Naturae Magia Scientiarum omnium apicem, Artium florem, occultorum scrutatricem, mirabilium effectricem, cui artes omnes, omnes famulantur scientiae … "

[17] Schott, *Magia universalis*, vol. I, *Prologus Encomiasticus ad Lectorem*, p. iii.

[18] Schott, *Magia universalis*, vol. I, p. iv.

[19] Schott, *Magia universalis*, vol. I, p. vi.

rhetoric here was of nature knowing itself, of finding its proper arrangement and direction, through the intervention of artifice.

Mohr's assurances that artifice will not surpass or transgress the limits of nature, but will instead elevate and guide, reflected the Peripatetic belief in art's inability to supersede the powers of nature. Such claims, however, also clarify the way in which both Mohr and Schott proposed to use artifice in its joining with nature: as a means to both guide and elevate the latter, but also as the means whereby nature discovers its own limits. Significantly, this notion of art instructing nature also appeared in Kircher's *Mundus subterraneus*—another text devoted to the joining of art and nature—where he claimed that, "if an effect of nature should be produced by art, at the same time, in this display, nature is taught by art to reveal [itself]" (*si per artem naturalis effectus producatur, eadem arte naturam in eo producendo procedere docetur*).[20] Here, then, was a clear articulation of Schott's desire to reveal the boundaries of nature. Like Kircher, he was convinced that one could use artifice to instruct nature, to encourage it to reveal itself to the gaze of the artificer. It was a desire that Schott also expressed in later works such as the *Technica curiosa* but that here, in the *Magia*, focused not only on varied examples of artifice but also on those parts of nature that must be revealed and explained before they can be understood.

Schott's basic notion of "magic" followed almost exactly the definitions provided by Martín del Rio in his *Disquisitionum magicarum libri sex* of 1599, which Schott acknowledged as one of his sources.[21] Schott and Del Rio both defined natural magic as the application of actives to passives, or agents to patients, which varied only in the time, place, and manner of application, and which only appeared to be a trick or miracle to those ignorant of the causes.[22] Schott then defined artificial magic simply as the production of wonders (*mira*) through human industry and with the aid of various instruments.[23] These were standard definitions for the time, but they are peculiarly unhelpful within the wider context of the *Magia*, which sought repeatedly to erase the

[20] Athanasius Kircher, S.J., *Mundus subterraneus*, 3rd edn, vol. II (Amsterdam: Joannem Janssonium & Elizeum Weyerstraten, 1678), p. 9.

[21] Schott, *Magia universalis*, vol. I, p. 9.

[22] Schott, *Magia universalis*, vol. I, p. 19: "Naturalem Magiam appello, reconditam quandam arcanarum Naturae notitiam, quaererum singularum naturis, proprietatibus, viribus occultis, Sympathiis ac antipathiis cognitis, res rebus, seu ut Philosophi loquuntur, activa passivis, suo tempore, loco, & modo applicantur, & mirifica quaedam hoc pacto perficiuntur, quae causarum ignaris praestigiosa, vel miraculosa videntur."

[23] Schott, *Magia universalis*, vol. I, p. 22: "Artificialem Magiam appello, artem seu facultatem mira quaedam perficiendi per humanam industriam, adhibendo ad id varia instrumenta."

separation between natural and artificial. Perhaps Schott saw this as a sop to the more conventional sensibilities of the censors, much as Kircher had included Peripatetic musings on the magnet before embarking on the decidedly non-Peripatetic project of his *Magnes*.

The juxtaposition of art and nature at the core of the *Magia* took a dizzying variety of forms, and was couched in a grandiose and flowery language that made the sober experimental accounts of Boyle and Hooke seem drab by comparison. Ultimately, however, Schott's "universal magic" was a program for an operational philosophy in which the products of art were brought to bear on the study of nature. This was certainly not the rather more restrained experimental philosophy of the Royal Society, but it was comparable in its essentials. For example, as part of the first volume of the *Magia* Schott proposed to discuss *Parastaticus*, "the prodigious representations of things made by Nature and Art"; this included the wondrous representations made by Nature "in the air, in mountains, in rocks, stones, plants, and other things"—in other words, marvelous images found in mundane objects. He then added, "And lest Nature should seem to have conquered Art, we show how to represent these same things through Art, and by means of a prodigious magic, or at least an elegant and delightful magic."[24] Thus, whatever Nature can do, Art can do as well.

The implication hidden in Schott's rather prosaic discussion was that, as the human artisan learns how to duplicate the prodigious feats of Nature, he comes to understand the hidden causes of those feats at the same time. One finds this theme repeated throughout the other books of the first volume of the *Magia*, which focused on the magic of optics, including the use of mirrors to produce bemusing spectacles (recall Kircher's *theatrum catoptricum*) and the focusing of light through lenses to produce heat and fire. Intriguingly, Schott ended this first volume with a final book devoted to "Telescopic magic; or, On the making, use, and prodigious effect of the telescope and microscope."[25] After rehearsing the early history of the telescope, which contemporaries recorded as appearing first in 1609, Schott noted that Niccolò Cabeo had reported hearing of a rudimentary telescope even earlier than this: a device with two lenses, one concave and one convex, "used in one's recitation of the Canonical Hours, with

[24] Schott, *Magia universalis*, vol. I, p. 5: "Parastaticus est, sive de prodigiosis repraesentationibus rerum à Natura & Arte factis; quem in finem variae ac prorsus admirabiles repraesentationes à Natura facte in aëre, in montibus, in rupibus, lapidibus plantis, aliisque rebus afferuntur. Et nè Artem Natura vincere videatur, eadem etiam, & magis prodigiosa, saltem magis concinnè ac jucundè, per Artem repraesentare docemus."

[25] Schott, *Magia universalis*, vol. I, p. 488: "De Magia Telescopica, sive, De fabrica, usu, et effectu prodigioso Telescopii & Microscopii."

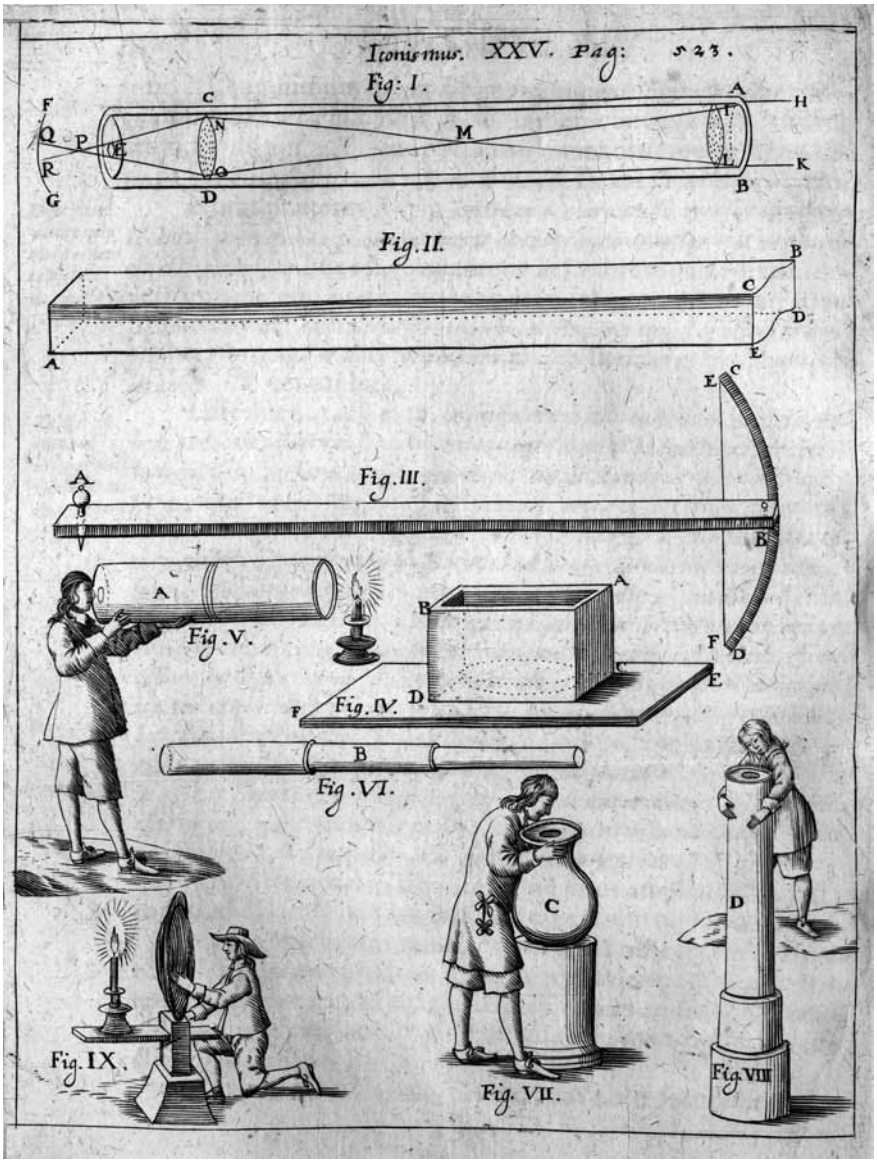

Figure 6.1 Various depictions of telescopes and similar devices, from Volume I of the *Magia universalis*.

Source: Courtesy Linda Hall Library of Science, Engineering and Technology.

the concave [lens] being applied close to the eye [and] the convex close to the book."[26] Schott also believed that Giambattista della Porta had predicted the construction and use of the telescope earlier still, in his *Magia naturalis* of 1589, and noted as well that "optical tubes would seem to have been used" in antiquity.[27]

It is perhaps unsurprising that figures like Galileo and Kepler received little mention in Schott's historical account of the telescope; instead, Schott seems to have veered carefully away from any discussion of the cosmological controversies sparked by the use of the telescope earlier in the century. It is noteworthy, however, that the frontispiece of the *Magia* features prominently the two cosmological systems accepted by the Society of Jesus, the Ptolemaic and the Tychonic; one of the female figures clutches in her hand a telescope, while the other points to *putti* arranging the heavens above. There we see the fruits of early modern telescopic observation: the crescents of Mercury and Venus, the cratered surface of the moon, Jupiter surrounded by its own four moons, and Saturn with its "handles." The design is strikingly similar to the frontispiece of Giovanni Battista Riccioli's *Almagestum novum*, which appeared in 1651 and which featured putti holding aloft these same representations of the planets, but which featured the Tychonic and Copernican cosmological systems. Riccioli, a Jesuit, devoted considerable space in his work to a comparison between those two systems, and it is noteworthy that Schott, only a few years later, went so far as to avoid even a representation of the Copernican system on a frontispiece that appears to be inspired by Riccioli's work.[28]

There seems relatively little in Schott's discussion of the telescope that one could term "magic"; instead, most attention was paid to how to construct and use the instrument. Nonetheless, the real focus of this discussion was one simple principle: the revelation of natural secrets through artifice, with Schott predicting the new and wondrous revelations that awaited further refinements of this instrument. His discussion of the microscope was significantly shorter, presumably because in 1657 the microscope had been in use for a shorter span of time than had the telescope, but here, too, Schott praised the "wondrous virtue" of its "showing the hidden structure of natural things."[29]

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[26] Schott, *Magia universalis*, vol. I, p. 491.

[27] Schott, *Magia universalis*, vol. I, pp. 492–3.

[28] On the strong links between Jesuit astronomy and the system of Tycho, see Kerry V. Magruder, "Jesuit Science After Galileo: The Cosmology of Gabriele Beati," *Centaurus*, vol. 51 (2009), pp. 189–212; Allan Chapman, "Tycho Brahe in China: The Jesuit Mission to Peking and the Iconography of European Instrument-Making Processes," *Annals of Science*, vol. 41 (1984), pp. 417–33.

[29] Schott, *Magia universalis*, vol. I, p. 536: "De Virtute mirabili Microscopiorum, in rerum naturalium occulta constitutione ostendenda."

Figure 6.2 The frontispiece to the *Magia universalis*.
Source: Courtesy Linda Hall Library of Science, Engineering and Technology.

References to revelation certainly make sense in a volume devoted to optics. They might seem to make less sense, however, in the next volume, devoted to the magic of sound and acoustics. The extended title of this volume promised to discuss all aspects of sound, divided between theory and practice, and with the aid of analogies to vision, light, and colors, all of these things "established by

practices [*praxibus*] and experiments." What followed in the succeeding pages was a range of topics, from the anatomy of animals (including humans) that permits them to vocalize sounds, to ruminations on music theory and examples of machines capable of producing sound. The pervasive theme throughout was not so much the revelation of natural mysteries, but rather the exuberant intermingling of nature and artifice; over the course of this volume, the two became almost indistinguishable from one another, with the principles at work in one (such as the vocal cords) replicated and emulated in another (such as musical instruments).

Towards the end of the volume, Schott addressed "music various or rare," noting that noises that would be considered "vile" if heard daily become more sweet when encountered but rarely: "For often the excessively discordant singing of men and animals, and the noises of instruments, more delight the ears and restore the soul than the comparable music of the angels; not that which is as pleasing as possible, but that which is more rare."[30] There is a curious similarity here with the contemporary culture of marvels that Schott was scrutinizing, and perhaps even a subtle justification for his wider enterprise in the *Magia*: that which is rare has a greater effect than that which is encountered daily, and so all the more reason to focus on those rarities. He also included a somewhat implausible description of "the music of donkeys": the trick, according to Schott, lay in using male donkeys of particular natural pitches and stimulating them to bray with the urine of a female donkey, which will induce the males to make "most contented" noises that the generous might construe as a kind of music. After this came another "musical" invention, attributed to Kircher, that involved placing cats of differing sizes and constitutions in a modified harpsichord. When a key was pressed, a hammer or spike would hit a cat's tail, causing it to yowl at a certain pitch.[31]

Neither of these "instruments" seems particularly magical at first glance—nor, for that matter, philosophically instructive. Indeed, Schott characterized them as examples of entertainment, with the feline harpsichord in particular designed to "move men to laughter" (Kircher had conceived of the instrument in an effort to cheer a melancholy prince of his acquaintance). Nonetheless, however

[30] Schott, *Magia universalis*, vol. II, p. 371: "Saepe enim absoni admodum hominum & animalium concentus, Instrumentorumque soni, plus aures delectant, animum recreant, quàm Musica Angelicae aemula; non quòd illa quàm haec suavior, sed quòd rarior."

[31] Schott, *Magia universalis*, vol. II: "*Asinorum Musica*," pp. 371–2; the cat harpsichord, pp. 372–3. For more on the latter invention, see Thomas L. Hankins, "The Ocular Harpsichord of Louis-Bertrand Castel; Or, The Instrument That Wasn't," *Osiris*, 2nd series, vol. 9 (1994), pp. 141–56.

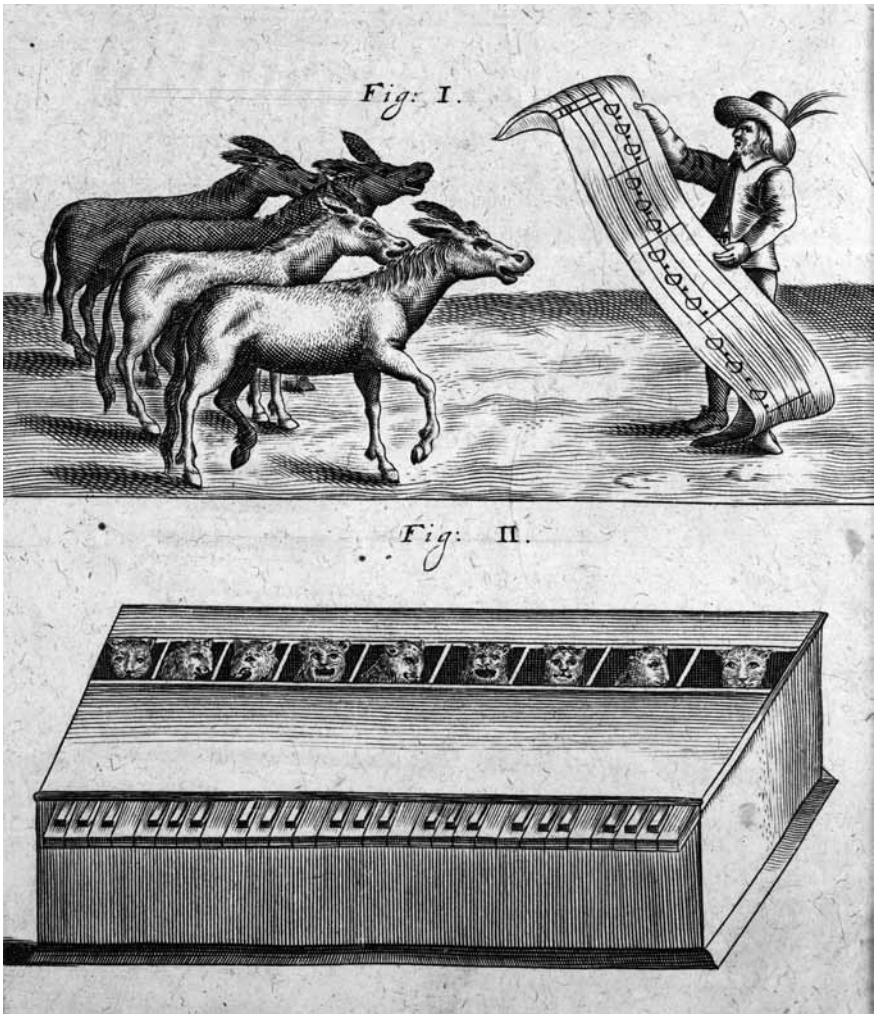

Figure 6.3 *Asinorum musica*, or Schott's donkey choir; below, the feline harpsichord attributed to Kircher.

Source: Courtesy Linda Hall Library of Science, Engineering and Technology.

light-hearted and entertaining they were, the singing donkeys and the feline harpsichord were also evocative demonstrations of the joining of artifice and nature: the vocal cords of the screeching cats became a natural analogue to the plucked strings of the conventional instrument, and in the function of one Schott's audience came to understand the properties of the other. The inclusion

in the *Magia* of such imaginative devices suggests that Schott was interested in spurring an equally imaginative contemplation of the possibilities inherent in the juxtaposition of nature and art, just as Kircher did throughout his own works.

The third volume of the *Magia* focused on various examples of applied mathematics, or what contemporaries called "mixed" mathematics, including *Centrobaryca, Mechanica, Statica, Hydrostatica, Hydrotechnica, Aerotechnica, Arithmetica, & Geometria*. At first glance, the principles of hydrostatics or geometry hardly merit much praise, but Schott was so taken by their potential in producing marvels that he added as an aside, "Deservedly, this work should be called *Mathematical Thaumaturgy*." The entire volume shared important similarities with the wondrous Kircherian machines in the Collegio Romano, with frequent suggestions as to how best to bemuse and startle a receptive audience with these displays of mathematical magic. At the same time, it was itself a bemusing jumble of things and ideas; in relatively short order one moved from anecdotes of the ancient craftsman Daedalus using quicksilver to animate a statue of Aphrodite to a proposed *quadriga* or cart that could move "without horses," and from the devices used by Domenico Fontana to relocate a massive Egyptian obelisk on the grounds of the Vatican in 1586 to a disquisition on the possibility of moving the entire Earth (if it were made of solid gold) by applying only a single talent, or approximately 75 pounds, of force with the use of a *glossocomum*, a series of toothed wheels that synergistically multiply their force when used in concert.[32] This last example was borrowed (without attribution) from an unpublished manuscript by Christoph Grienberger, the former mathematics professor in the Collegio Romano, and Schott's musings on the potential power of artifice—capable of shifting the world if applied properly—stand as a poignant evocation of that famous statement of Archimedes, "Give me a lever and a firm place to stand and I will move the world."

Schott's unswerving faith in the potential of artifice to uncover nature's secrets also encouraged him to repeat the rhetoric he used in the first volume of the *Magia*, where either nature or artifice sought to conquer the other. For example, on the subject of "mechanical magic" Schott proclaimed, "There is no Art, no Science, that more manifestly seems to conquer Nature

[32] Schott, *Magia universalis*, vol. III: on Daedalus, see p. 273; "*Quadrigae sine hominum aut jumentorum trahentium ope per vias agitate … quae sine equis antrorsum et retrorsum progrediebatur*," attributed to "D. Georgius Philippus Harstorfferus," p. 259; for a description of the procedures used to move and erect the obelisk, see p. 297; for Schott's musings on the possibility of shifting the Earth, see pp. 236–41.

than Mechanics."[33] In many respects, however, this entire volume of the *Magia universalis* is rather prosaic. While Schott was willing to describe the application of mathematics to various tasks, it comes across more as a collection of anything and everything to do with the mixed mathematical disciplines, rather than as a focused disquisition on "magic."

The fourth and final volume of the *Magia* bore the title, "*Thaumaturgus Physicus*," and promised to discuss everything from pyrotechnics and magnetism to curatives and chiromancy. At the heart of this volume lay an apparent dichotomy that would reappear in the later *Technica curiosa*, between a language of magic and mysteries on one hand and the philosophical exploration and explanation of those same mysteries on the other. This appeared, too, in the volume's complete title, where Schott promised to discuss "all that is rare, curious, and prodigious, that is, truly magical ... illustrated by innumerable examples and experiments ... and either affirmed or rejected by physical reasons."[34]

Thus, one finds a juxtaposition of two separate languages: one of seeming esotericism, the other of natural philosophy and, more specifically, physics. As an example, Schott turned to a Peripatetic vocabulary of qualities and propagation in his discussion of sympathetic and antipathetic magic, in an attempt to explain why disparate objects influenced one another without appearing to touch. Echoing Niccolò Cabeo almost exactly, Schott outlined three different kinds of contact: the sensible propagation of a particular species as in heating and cooling, the occult propagation of an insensible species as in magnetism, and the emission of particles or corpuscles that carried scent from substances like wine and vinegar.[35] With the exception of corpuscles—branded in 1651 as philosophically unsound in the Society's guide to teaching and curricula, the *Ordinatio pro studiis superioribus*—this was a standard, Peripatetic explanation for a range of typical occult phenomena. Schott then juxtaposed this, however, with the decidedly non-Peripatetic practice of dowsing for buried metals with a forked stick and a discussion of the sympathy between mercury and gold. The

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[33] Schott, *Magia universalis*, vol. III, p. 88: "Nulla enim Ars est, nulla Scientia, quae evidentiùs Naturam superare videtur, quàm Mechanica."

[34] Schott, *Magia universalis*, vol. IV. The full title of the volume reads: "Thaumaturgus physicus, sive Magiae universalis naturae et artis ... Quibus pleraque quae in Cryptographicis, Pyrotechnicis, Magneticis, Sympathicis ac Antipathicis, Medicis, Divinatoriis, Physiognomicis, ac Chiromanticis, est rarum, curiosum, ac prodigiosum, hoc est, vere magicum, summa varietate proponitur, varie discutitur, innumeris exemplis aut experimentis illustratur, solide examinatur, & rationibus physicis vel stabilitur, vel rejicitur."

[35] Schott, *Magia universalis*, vol. IV, p. 367.

Magia consequently fulfilled its promise to "bring forth" the secret marvels and wonders of nature through, at least in part, attempts at philosophical explanation.

True to the earlier volumes of the *Magia*, Schott also mingled together nature and artifice in a variety of ways. For example, consider his discussion of "pyrotechnic magic," which he further defined as concerned with "varied and prodigious experiments, spectacles, and machines of artificial fire."[36] His focus was not merely on artificial fire, however. Alongside descriptions and explanations of Greek fire, perpetual flames, and *pulvis pyrius*—literally "fiery powder," or gunpowder—Schott included a lengthy discussion of the *pulmo marinus* first described by Pliny: bioluminescent jellyfish that often washed up onto shore.[37] Schott thus mingled the artificial and the natural, presenting them alongside one another with the implication that the light and heat produced artificially by chemical reactions and other examples of artifice mirrored in some way the light produced naturally by marine life.

One also encounters in the *Magia* the same curious practice that Schott would later employ in the *Technica curiosa*: an insistence on referring to phenomena as *mirabilia* or marvels while, at the same time, rendering them comprehensible, if not commonplace, by stripping away their elements of mystery and describing their inner workings and principles in particular detail. As an example, in the *Magia* Schott referred to "the impenetrable nature and properties of the magnet" and also characterized the magnet as "a stupendous miracle of nature" and "the labyrinth of the philosophers."[38] A reader encountering such phrases might be forgiven for believing that Schott himself had been stymied by the labyrinthine, "impenetrable" magnetic nature, but in fact the following hundred pages demonstrated in exhaustive detail that Schott had been neither stymied nor deterred in describing the properties of the magnet and their application to a variety of tasks and spectacles.

One might connect Schott's apparent fondness for characterizing exotic phenomena as marvels and wonders with claims that, like Kircher, Schott was doing little more than reveling in the mysteries of nature.[39] Merely playing with nature's secrets, however, would have availed Schott and Kircher nothing. By contrast, the demonstration and exhibition of nature's secrets could have afforded them considerable intellectual notoriety in a period when numerous

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[36] Schott, *Magia universalis*, vol. IV, p. 97: "De Magia Pyrotechnica; sive, De variis ac prodigiosis artificialium ignium experimentis, spectaculis, ac machinis"

[37] Schott, *Magia universalis*, vol. IV: for Greek fire, see p. 122; on perpetual flames, p. 150; *pulvis pyrius*, p. 182. On the *pulmo marinus*, see p. 102.

[38] Schott, *Magia universalis*, vol. IV, p. 225.

[39] Evans, *The Making of the Habsburg Monarchy*, p. 344.

individuals were trying to exhibit the same things.[40] Moreover, Schott could only sketch the boundaries of the natural if the hidden reaches of the world were exposed and unveiled, and thus simply leaving these things secret and unknown would accomplish very little.

Indeed, in an important sense Schott's works fulfilled the same purpose as Kircher's figurative and emblematic illustrations. We might look to the images Kircher included in the *Magnes* or the *Mundus* and wonder why they described phenomena and devices that either never existed or could not exist as rendered therein. If Kircher's purpose in commissioning and including these images, however, was not to transmit accurate or "true" information about the natural world but rather to encourage the imaginative reader to contemplate the world for himself, then we can understand Schott's project as embracing a similar set of goals. Schott was not necessarily using the *Magia universalis* to explain every phenomenon under consideration, particularly as at least some of those phenomena possessed only a tenuous link, if any, to genuine principles of natural knowledge.

In spite of this, however, there lay at the core of the *Magia* Schott's insistence that artifice could both elevate and direct nature, a philosophy that lay very close to the experiential and experimental practices embraced by institutions like the Royal Society. The English virtuosi hoped to secure the most likely and useful knowledge of nature through active intervention and manual labor—by getting their hands dirty, to paraphrase Robert Boyle.[41] Experiment was the means whereby reason could be brought to bear on sense-experiences, thereby securing the most probable knowledge of how nature worked. Schott went further still in the *Magia*, however; like his mentor, Athanasius Kircher, he claimed that artifice could instruct nature in its own limits, and might in turn instruct us in where those limits lie.

We have seen in previous chapters that contemporary intellectual crises involved the active redefinition of the boundaries between different kinds of things: recall the debates over the weapon salve and the efforts made to define it either as natural, supernatural, or something else altogether, or Martín del Rio's struggles with the ontology of magic. The study of the unseen was in flux at the precise moment that Schott wrote his *Magia universalis*, and it is clear that the *Magia* was itself part of this ongoing redefinition of phenomena. When Schott

[40] See, for example, Eamon's *Science and the Secrets of Nature*, which records numerous examples of early modern thinkers and their attempts to exhibit nature's secrets to a wide range of audiences.

[41] Steven Shapin, "The Invisible Technician," *American Scientist*, vol. 77 (1989), pp. 554–63.

juxtaposed Greek fire and gunpowder with the glowing bodies of jellyfish, his goal in doing so was not merely to contrast a natural effect with an artificial one, but to mingle both effects together and thereby encourage us to contemplate a kind of "fire" that lay somewhere along the ever-shifting line between nature and artifice, one that became less marvelous with the more particulars—in the Baconian sense—he provided. Indeed, I suggest that Schott's project here was, in at least some sense, thoroughly Baconian: in his enthusiastic and eclectic intermingling of phenomena and objects, he was fashioning his own kind of history—not, perhaps, Bacon's idea of "natural history," but something novel in which innumerable particulars of nature and artifice were brought together to create a record that testified to the marvelous diversity and ingenuity of Creation.

The *Technica curiosa*

While an excellent example of his predilection for revelation, Schott's later *Technica curiosa* also underscored his commitment to artifice and experiment as part of that revelation. The full title, *Technica curiosa, sive Mirabilia artis*, testified to Schott's focus on "the wonders of art," and the title page promised that one would find a variety of arts discussed within, including "the secret, miraculous, rare, curious, [and] ingenious."[42] Moreover, in the opening pages of the *Technica* Schott informed his readers that

> the chief purpose of the labors undertaken in these four volumes is to excite others toward the experimental philosophy. I have already shown ... how greatly that style of philosophizing pleases me, which is not dependent on the subtleties of words and cunning, but which examines thoroughly the concealed heart of Nature itself and which unites "to know" [*scire*] with "to be able" [*posse*] in a happy marriage.[43]

[42] Gaspar Schott, S.J., *Technica curiosa, sive Mirabilia artis, libris XII comprehensa ...*, 1st ed. (Nuremberg: Johannis Andreae Endteri & Wolfgangi Junioris Haerdum, 1664), title page: "Libris XII comprehensa; Quibus varia Experimenta, variaque Technasmata Pneumatica, Hydraulica, Hydrotechnica, Mechanica, Graphica, Cyclometrica, Chronometrica, Automatica, Cabalistica, aliaque Artis arcana ac miracula, rara, curiosa, ingeniosa, magnamque partem nova & antehac inaudita, eruditi Orbis utilitati, delectationi, disceptationique proponuntur."

[43] Schott, *Technica curiosa*, p. 5.

It is worth noting that this marriage of knowing and doing, of contemplation and action, echoed both Schott's talk of the marriage between art and nature in the *Magia universalis* and the dichotomy at the heart of Kircher's *Mundus subterraneus*. Though the *Technica* did contain a variety of curious and ingenious things however, there was little that Schott permitted to remain secret; the "concealed heart of Nature" did not, in fact, remain concealed for long.

Indeed, though filled with a persistent rhetoric of wonders, marvels, and arcane knowledge, the *Technica curiosa* actually functioned as an elaborate exercise in revelation. It opened the mysterious innards of particular machines, set forth mathematical and linguistic methods of representing the natural world, and demonstrated that it could explain and expose even the most curious and ingenious of objects. After explaining so thoroughly the principles that informed these demonstrations of artifice, after laying open the machines and devices themselves and demonstrating not only how they operated but also how they explained and emulated natural processes, Schott could hardly claim with any real validity that what he described was truly wondrous or difficult to understand. His practice of offering with one hand the rhetoric of wonder and dismantling it with the other forces us as his readers to question why he might have used this language in the first place. It makes sense to link Schott's rhetorical practices here with the evolving intellectual culture of the day. His habit of marking phenomena and objects as wonders or mysteries before uncovering their causes was a kind of staged *venatio*, a hunt for nature's secrets on Schott's own terms.[44] But it also demonstrated that appearances can be deceptive: what seems to be an intractable puzzle is, instead, merely a rather prosaic philosophical demonstration, and we are left to marvel at both the mysteries of nature and the limits of our own understanding.

The *Technica* opened with the work of Otto von Guericke, whose experiments Schott had included in his earlier *Mechanica hydraulico-pneumatica* and which had made that work very popular with readers. Schott included several letters from Von Guericke in the *Technica*, and described in detail the man's many pneumatic experiments, including the famous Magdeburg spheres, metallic hemispheres that, when evacuated of air, could not be separated by teams of horses pulling in opposite directions. Von Guericke and others had used this example to establish the existence and strength of the vacuum, and while Schott contented himself at first with merely describing Von Guericke's work

[44] For more on the early modern concept of the *venatio*, see Paolo Rossi, *Philosophy, Technology, and the Arts in the Early Modern Era*, trans. S. Attanasio (New York: Harper & Row, 1970), p. 42.

and subsequent conclusions, he eventually proposed his own explanations for these phenomena, after first describing the "Mirabilia Anglicana," or "English marvels" wrought by Robert Boyle's experiments with the air pump.

Figure 6.4 Schott's depiction of the Magdeburg pneumatic experiment, from his *Technica curiosa*.

Source: Courtesy Linda Hall Library of Science, Engineering and Technology.

Ostensibly committed as he was to an Aristotelian philosophy, Schott denied the existence of the vacuum in a subsequent section of the *Technica* entitled "A physical scrutiny of the preceding experiments," meaning those described and illustrated in the preceding three books, all of which were pneumatic in nature.[45] Schott claimed that the experiments performed with Von Guericke's spheres, Boyle's air pump, and Torricelli's glass tubes had not established the existence of a vacuum because "glass has pores" through which materials could flow, and that the aether "fills every space," including the seemingly empty chamber of the pump or tube once the air has been evacuated. He did, however, embrace a view similar

[45] Schott, *Technica curiosa*, p. 214: "Scrutinium physicum praecedentium experimentorum." For early modern and, particularly, Aristotelian objections to the vacuum, see Edward Grant, *Much Ado About Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution* (Cambridge: Cambridge University Press, 1981).

to Boyle's when he suggested that the air possessed an elastic virtue or force that might explain some of the results witnessed in these various experiments.[46] Thus, here as in the earlier *Magia universalis*, Schott's work was neither uncritical nor encyclopedic; it was instead a careful description of reported experiments followed by an equally careful Peripatetic analysis of the results.

In subsequent books of the *Technica*, Schott described "hydrotechnic wonders"—fountains, for the most part—and "mechanical wonders," including a number of perpetual-motion machines. What was striking about Schott's description of these wonders was the manner in which he exposed to the reader's eye the means by which these "marvels" functioned: in the case of the fountains, for example, he included numerous illustrations that juxtaposed the fountain itself with the actual mechanisms that permitted it to work, superimposing these mechanisms onto a plain wall to indicate that they would normally be hidden from view. The accompanying text promised to explain to the reader how these devices worked (he repeated the phrase *explicatio praecedentis machinae* many times) and duly described the function and purpose of the many components illustrated on the preceding pages, sometimes also including instructions on how to build such machines.[47]

Recalling that Schott wrote his earlier *Mechanica hydraulico-pneumatica*, upon which he based the *Technica*, as a catalogue of the pneumatic and hydraulic devices in Kircher's museum, we might interpret this particular example of Schott's work as a similar exercise in showmanship and spectacle, bringing to a much wider audience the wonders displayed by his mentor as well as those shared with Schott himself by his numerous correspondents. He describes, for example, the *Fonticulus Kircherianus*, a device shaped like the two-headed imperial eagle of the Hapsburgs that vomited water from both heads. Similar examples included a device in the shape of a crayfish that, when hooked over the edge of a goblet as if trying to escape from within, sucked in water with its tail and vomited it from its mouth. Schott's *Technica* thus worked to expand the boundaries of Kircher's museum; he was propagating in print what Kircher had already sought to accomplish *viva voce*.[48]

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[46] Schott, *Technica curiosa,* p. 295: "Aëris elastica vis experimentis probatur."

[47] For example, p. 361 describes how to build an ornate fountain—*Constructio Machinae*—illustrated on the facing page.

[48] Vomiting machines were, apparently, a central feature of Kircher's collection in Rome; see Michael John Gorman, "Between the Demonic and the Miraculous: Athanasius Kircher and the Baroque Culture of Machines," in Daniel Stolzenberg, ed., *The Great Art of Knowing: The Baroque Encyclopedia of Athanasius Kircher* (Stanford: Stanford University Libraries, 2001), pp. 59–70.

The revelatory tone that pervaded the *Technica curiosa* was made explicit when Schott turned his attention to a tract written by Kircher, the *Specula Melitensis Encyclica*, originally produced in 1638 and thus among his first works. This "Maltese Observatory," so-called because Kircher originally dedicated the treatise to the Knights of Malta and supposedly constructed the device on the island itself, was intended by its author to function as a "new [type of] physico-mathematical machine." Kircher's insistence on designating this device as an observatory—a high place from which one can see what might be otherwise obscured—is itself suggestive of its role in bringing to view numerous natural correspondences and phenomena; as he explained it, he chose the term *specula* because "[the principles of] astronomy, geography, hydrography, physics, and medicine are exposed to the eye."[49] Kircher claimed that his Observatory was capable of everything from charting the movements of the planets and predicting storms and winds to establishing the times and locations of future eclipses and "discovering medical agents with occult powers," making it arguably one of the greatest examples of the revelatory powers of artifice found in any of his, or Schott's, works.

Kircher's Maltese Observatory operated by virtue of the correspondences between disparate things, an idea that we already know lay at the heart of his natural philosophy. Indeed, the Observatory was itself an artificial device that displayed the changing currents in the wider world, calibrated so as to detect and measure these changes and thereby permitting the learned artificer to predict future events such as eclipses and storms. Moreover, the Observatory echoed Kircher's words to the Emperor Leopold in the *Mundus subterraneus*, where he promised that the text itself would work as a piece of artifice, exposing to Leopold's eye the depths of the Earth. We should recall, however, that Kircher's dedication to the Emperor was also layered with notions of dominion, utilization, and manipulation. The *Mundus* permitted its user to do more than merely observe the world; it permitted him to control it as well. The Maltese Observatory described by Kircher shared a similar purpose: those who used it did not simply observe the unseen correspondences between things, but could actively manipulate them in the production of medicines and, more broadly, of natural knowledge.

Unlike every other example of artifice described and illustrated in the *Technica curiosa*, Kircher's *Specula Melitensis* was not subjected to analysis and explanation. Schott never tried to demystify this device for his readers as he did with the devices of Von Guericke, Robert Boyle, and others. Instead, he left us

[49] Schott, *Technica curiosa*, p. 428.

only with Kircher's explanations, such as they were. It is possible that Schott felt himself unequal to the task of properly explicating his mentor's project, though it is also possible that, by placing Kircher's *Encyclica* at the literal heart of the *Technica* and leaving the elder Jesuit to speak for himself, as it were, Schott was bestowing the *imprimatur* of his mentor on his own project, linking his descriptions, illustrations, and experiments with Kircher's insistence on rendering the natural world "exposed to the eye" of his readers.

Following the *Specula Melitensis Encyclica*, Schott went on to detail the properties of a proposed artificial language—inspired by Kircher's 1663 *Polygraphia*—and claimed that such a work of art presented the best hope for "a universal key to the language of the entire world," discussing these "written marvels" as a means of representing the natural world in its entirety.[50] This constitutes another facet of revelation, for many thinkers in the seventeenth century who focused on artificial and universal languages saw them as a way of depicting the links between natural objects and thereby opening up the depths of nature to human scrutiny and understanding.[51] In the final book of the *Technica*, Schott examined another revelatory language, the cabala, or in his words, "Cabalistic wonders, or, the Cabala of the Hebrews lucidly explained, accurately examined, and sincerely judged,"[52] Following as it does books devoted to chronometric and automatic marvels, Schott's discussion of the cabala might appear out of place at first glance, and yet the principles that he discussed actually fall into alignment with the rest of the treatise, with an emphasis on the uses of the cabala—a human art—in revealing hidden knowledge of the world, and on its status as a "secret art," appreciated and understood only by select adepts. Schott himself chose to take a fairly neutral stance on the cabala, claiming that he could neither wholly praise nor wholly condemn it but saw both good and bad, useful and noxious joined together within it.[53]

Schott's interest in the cabala is unsurprising; his mentor Kircher had a long-standing fascination with it as well.[54] In turn, Kircher inherited this fascination

[50] Schott, *Technica curiosa*, p. 505.

[51] This view was held by one of the foremost universal language theorists of the seventeenth century, John Wilkins; see his *Essay Towards a Real Character and a Philosophical Language* (London, 1668). For more on sevcenteenth-century universal language schemes, see M.M. Slaughter, *Universal Languages and Scientific Taxonomy in the Seventeenth Century* (Cambridge: Cambridge University Press, 1982); James Knowlson, *Universal Language Schemes in England and France, 1600–1800* (Toronto: Toronto University Press, 1975).

[52] Schott, *Technica curiosa*, p. 896.

[53] Schott, *Technica curiosa*, p. 1019.

[54] Daniel Stolzenberg, "Four Trees, Some Amulets, and the Seventy-Two Names of God: Kircher Reveals the Kabbalah," in Paula Findlen, ed., *Athanasius Kircher: The Last*

from more than a century of Christian commentaries on the cabala, beginning in the latter decades of the fifteenth century when Giovanni Pico della Mirandola first tried to reconcile the fundamental precepts of the cabala with a Christian perspective in pursuit of a contemplative and mystical union with the divine.[55] Interest in the cabala persisted well into the seventeenth century, so Schott was far from alone in devoting a portion of his *Technica* to this art; like many among his contemporaries, he saw in the cabala a potential means of addressing and solving existing problems that extant traditions had either ignored or were inadequate to resolve.[56]

For some early modern thinkers the cabala offered yet another solution to the intellectual crises of the day, an alternate framework in which they could order and understand the world. Taken in this light, Schott's interest in the cabala as well as its placement in the *Technica* both make sense: as with the universal languages, the cabala offered Schott the opportunity to unlock the mysteries of nature and then make them manifest to the eyes of his readers. He first pointed to a division within the cabala between *Mercava* and *Beresith*, with the former concerned with a knowledge of divine things—"that which revolves around God, the true Creator of all things,"[57] such as the various names of God and the ten Sephiroth—and the latter with natural or created things. In his definition for the *Beresith* cabala, Schott intriguingly presented this particular art in the same terms as those used by many to describe natural magic, as a joining of active with passive in the production of a particular, wondrous effect.[58] Consequently, the cabala assumed for Schott the same potential as natural magic, another parallel drawn between the human arts and the hidden powers of nature. In concluding his discussion of the cabala, Schott noted its utility in revealing and uncovering the mysteries of the Trinity as well as the mysteries of the natural world.[59]

We should recall that Kircher chose to end his *Magnes* on a spiritual note, encouraging his readers to see the invisible force of the magnet as not merely an

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Man Who Knew Everything (New York: Routledge, 2004), pp. 143–64.

[55] Brian P. Copenhaver, "The Secret of Pico's *Oration*: Cabala and Renaissance Philosophy," *Midwest Studies in Philosophy*, vol. 26 (2002), pp. 56–81.

[56] William J. Bouwsma, "Postel and the Significance of Renaissance Cabalism," *Journal of the History of Ideas*, vol. 15, no. 2 (1954), p. 232. See also Philip Beitchman, *Alchemy of the Word: Cabala of the Renaissance* (Albany: SUNY Press, 1998).

[57] Schott, *Technica curiosa*, p. 961: "illa enim circa DEUM verum omnium conditorem."

[58] Schott, *Technica curiosa*, p. 990: "Alii in entium naturalium ordine & connexione mutuam, quam inferiora mediis, media secundis conjuguntur; vel potius in eiusmodi ordinis cognitione eam constituunt: unde ex analogia & proportione singulorum ad alia, per applicationem activorum cum passivis mira se praestare posse putant."

[59] Schott, *Technica curiosa*, p. 1044.

analogue for the mysterious power of God, but also as fodder for an imaginative contemplation of the marvels of God's creation and His providential care for everything in it. In choosing to end the *Technica curiosa* with a discussion of the cabala, I believe Schott was attempting something similar. The cabala was an example of human artifice designed to illuminate the hidden mysteries of God, but so too were the air-pump of Robert Boyle and the vomiting machines of the Kircherian collection, which reified in their operation the laws and forces that governed Creation. For Schott as well as for Kircher, human artifice was important because it made visible the hidden intricacies of nature, those marvelous exemplars of God's power and will.

Upon reaching these last pages of the *Technica curiosa*, early modern audiences would have found themselves informed, perplexed, but also, perhaps, inspired. Schott had taken the mysteries of artificial magic and the baroque culture of machines enshrined in Kircher's Roman museum and laid them open time and again, revealing secrets on almost every page. At the same time, he presented his readers with a message that was surely as reassuring as it was bemusing: the secrets of nature were as vulnerable to demonstration and display as the machines exposed and dissected in the pages of his book. It was to artifice that naturalists should look to address the problems of uncertainty and mystery that still plagued natural philosophy, and there were crucial answers to be found even in the quixotic arrangement of cats in a makeshift harpsichord. It was an optimistic vision for a new kind of science that, if nothing else, deserves greater attention than it has received.

Conclusion

From the hypothetical demons that troubled Martín del Rio to Isaac Newton's theory of universal gravitation, the seventeenth century was marked by a steady preoccupation with the unseen. European naturalists wrestled with how to make sense of a universe that seemed to grow more uncertain all the time, even as technologies such as the telescope and microscope continued to reveal how little of that universe they actually saw. Given how central the unseen was to this period, it is unsurprising that the "new philosophies" of nature, those progenitors of modern science, actually embraced occult qualities and powers wholeheartedly, integrating the unseen into their very foundations.[1] This dependence on occult causes might be explained by the fact that, after the middle of the seventeenth century, many natural philosophers were "post-skeptics," the self-conscious beneficiaries of the previous century's struggles with skepticism and consequently reconciled to a study of nature based on probability rather than on certainty.[2] Thus, as thinkers became more comfortable with world systems that did not require demonstrative or empirical certainty, they also became more willing to invoke invisible causes to explain natural effects.

This reduction of visible phenomena to insensible fundamentals like atoms, corpuscles, or other invisible things was mirrored, albeit in reverse, by the efforts of Jesuits like Niccolò Cabeo, Athanasius Kircher, and Gaspar Schott. The philosophical works of these authors exposed invisible causes and phenomena to the gaze of the curious reader, bringing to bear on the problem of the invisible a powerful combination of imagery, artificial emulations of natural processes, and the rigors of Peripatetic logic. The stated intention of these authors was to render insensible causes both visible and comprehensible. Thus, while historians have puzzled over the seeming incongruity of the self-proclaimed enemies of Aristotle embracing a variant of Aristotelian occult qualities in their

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[1] Keith Hutchison, "What Happened to Occult Qualities in the Scientific Revolution?," *Isis*, vol. 73 (1982), pp. 233–53. For a more recent articulation of this same idea, see John Henry, "The Fragmentation of Renaissance Occultism and the Decline of Magic," *History of Science*, vol. 46 (2008), pp. 1–48.

[2] Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007), p. 330.

philosophical systems, a more important question is why ostensible proponents of Aristotelianism were working, at the same time, in the opposite direction: not only seeking to render the invisible manifest but also striving to abolish the very occult causes that the reformers denigrated so loudly and then embraced silently.

I have argued throughout this book that the Jesuits were driven in part by a desire for greater clarity, particularly when it came to the murky ontological space between the natural and the divine. Nature's secrets, its forces and causes that remained stubbornly resistant to investigation, were what made that boundary so perilous for early modern thinkers. For the Jesuits, dispelling those secrets became a necessity; only then could they point with certainty to the works of God. This insistence on guiding others to an understanding of things beyond the realm of the mundane lends an apostolic character to their efforts to illuminate the structure and boundaries of the world. The vision first fashioned by Ignatius Loyola encouraged simultaneously the illumination of the self and the enlightenment of others, and it expanded exponentially with the growing numbers of Jesuit colleges across Europe and beyond. This drive to educate others was what placed the philosophical elite of the Society squarely at the center of European intellectual life. At the same time, members of the Society were committed to a universal vision of a Church that spanned the known world as well as a single faith that would triumph over the bloody divisions that had fragmented Christendom. Their efforts to bring the imaginative visualizations of the Ignatian *Spiritual Exercises* to potential exercitants across Europe and beyond testified to a deeply rooted desire to share their vision of the universe with others, a desire expressed with eclectic vigor by Cabeo, Kircher, and Schott as much as by their contemporaries.[3]

Defining an ontology of the unseen, as several Jesuits did with the weapon salve, and abolishing the Aristotelian doctrine of occult qualities were steps taken towards a new kind of philosophy, one that privileged revelation over the occult causes that proliferated in the "new philosophies" of nature. The same was true of the spectacles engineered by Kircher in his Roman museum and later dissected by his disciple Schott. Unafraid as they were to question the utility of the eyes, even to encourage uncertainty, these men presented a probable vision of the universe that they tried to impress into the minds of their audiences. The invisible was familiar territory for the Jesuits, after all, and imagery and the imagination were both central to how they tried to make manifest the unseen.

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[3] Antonella Romano, "Understanding Kircher in Context," in Daniel Stolzenberg, ed., *The Great Art of Knowing: The Baroque Encyclopedia of Athanasius Kircher* (Stanford University Libraries, 2001), p. 410.

The Jesuits I have examined here understood, as did their contemporaries beyond the Society, that the familiar cannot be wondrous or marvelous in the same way as the unfamiliar or the unexplained.[4] It was in the juxtaposition of artifice and nature that Kircher and Schott in particular cast certain natural processes, those that were invisible, mysterious, or rare, as the workings of artifice—demonstrable, explicable, and presented to observation by illustration and experiment. Thus, nature itself became not only an example of artifice in its own right, as vulnerable to dissection and revelation as examples of human artifice, but an artisan as well, a skilled artificer whose work, at least in theory, the human craftsman could replicate.[5]

Presenting nature's most hidden and puzzling processes in terms of artifice reassured an early modern audience that, as in the machines displayed and discussed by Kircher and Schott, the skilled and knowledgeable manipulator could reveal, explain, and control such processes. They portrayed nature as a realm whose secrets had been exposed and illuminated, and the wonders ascribed to nature were now transferred to their own ingenuity. The cultural impact of nature's wondrous and hidden powers, which had defined European thought for centuries, shifted from the natural world to the artful and artificial worlds embodied in Kircher's museum, in the texts produced by Schott and Cabeo, and in the later work of contemporaries like Francesco Lana de Terzi. These men transformed the mysteries of the natural world into carefully controlled spectacles, and audiences visiting the Kircherian collection or reading these texts could not have failed to notice that what they actually displayed was not nature itself, but nature as interpreted and presented through the wonders wrought by Jesuit skill.

In the works I have analyzed here one finds the sober admission that, indeed, much of nature is mysterious and difficult to know, that our senses may trick or fail us, that ignorance and uncertainty are more common than we might wish. One also finds, however, the assurance that, however difficult nature might be, we still have the ability to teach it to reveal itself. These men encouraged their fellow Jesuits to abandon the pursuit of certainty and find new, innovative ways to study the world, thereby avoiding the pitfalls of dogmatism and sensual fallibility. Perhaps most importantly, they were willing to rewrite elements of their institutional philosophy to accomplish their goals. In this, they were no

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[4] Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998), p. 90.

[5] On the shift to seeing Nature as artisan, see Lorraine Daston, "The Nature of Nature in Early Modern Europe," *Configurations*, vol. 6 (1998), pp. 149–72.

different from their contemporaries beyond the Society of Jesus who were also struggling with the crisis of certainty.

I suggested in the opening pages of this book that these particular Jesuits were not outliers, and that we can and should understand their ideas as following from larger preoccupations that already existed within Jesuit intellectual culture. Without the pioneering efforts of Christoph Clavius and Martín del Rio, among others, the subtle and ingenious methods I have examined here might have looked very different. Did Cabeo and the others change Jesuit intellectual life, however? This is a far more difficult question to answer. At first glance, their attempts to render visible and knowable the myriad secrets of nature would seem to have met with stiff resistance from factions within the Society. Cabeo's novel quality of both motion and alteration was challenged—explicitly or otherwise—by the prohibitions of the *Ordinatio pro studiis superioribus*, and the light-hearted frivolities of Schott's *Joco-seriorum naturae et artis* earned him a reprimand from the Superior General of the Society. Kircher's struggles with the Society's censors have been well documented, and his reputation in Rome was as ambivalent as it was elsewhere.

While direct evidence of widespread influence remains to be found, however, there are hints that this concerted attack on nature's secrets did reverberate some distance within the Society as well as beyond its boundaries. The fact that the *Ordinatio pro studiis superioribus* required a general prohibition on the idea that there existed more than four primary qualities suggests that, by 1651, significant numbers of Jesuits were already teaching something along those lines. Cabeo's innovative work on the magnet may have inspired some of those teachings. Moreover, as fraught as Kircher's reputation was, he was one of the most public and widely read Jesuit thinkers of the seventeenth century; his works were cited by innumerable authors, and his ideas lived on not only in the works of his collaborator and disciple Schott, but also in works like Caspar Knittel's *Via regia ad omnes scientias et artes* and Gioseffo Petrucci's *Prodromo apologetico alli studi Chircheriani*, both of which appeared in the late seventeenth century.[6]

Whatever the wider influence of the ideas explored in this book, there is no doubt that this persistent preoccupation with the unseen, the myriad affirmations in these texts and in Kircher's museum that the disparate parts of the world were joined by hidden links and correspondences, worked together

[6] Caspar Knittel, *Via regia ad omnes scientias et artes; hoc est, Ars universalis Scientiarum omnium Artiumque arcana facilius penetrandi, et de qoucunque porposito themate expeditius differendi. Practice, clare, succincte.* (Prague: Universitas Carolo-Ferdinandea, 1682); Gioseffo Petrucci, *Prodromo apologetico alli studi Chircheriani* (Amsterdam: Janssonio-Waesbergj., 1677).

to shape a coherent intellectual tradition among the elite philosophers and naturalists within the Society of Jesus. The centerpiece and foundation of this tradition lay in demonstrating humanity's ties to the unseen parts of our world, and thence to the mysteries of God's beneficence and power. If it was greater clarity that these men sought, as I have argued, then ultimately it was a clearer vision of God that they struggled to place before the increasingly skeptical and uncertain gaze of their audiences. The secrets of nature, which had tantalized so many for so long, offered a superlative opportunity to peer into the hidden depths of God's works, and at least some Jesuits used this opportunity to make manifest both the secret intricacies of nature and the designs of their Creator.

Ultimately, Niccolò Cabeo, Athanasius Kircher, and Gaspar Schott found their inspiration as much in the rules and traditions of their shared community as they did beyond the confines of the Society. They were not interested in the coldly objective matters-of-fact and sterile mathematical principles that preoccupied contemporaries—many of them Protestant—elsewhere in Europe. These were men who witnessed miracles every day, and who participated in a faith that was both deeply sensual and warmly exuberant in its eclectic, sumptuous demonstrations of the divine presence. That presence became all the more tangible as the hidden secrets of nature fell away, exposed by imagery and spectacle and Jesuit ingenuity, until all that was left was *ad majorem Dei gloriam*—for the greater glory of God.

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